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This high-speed paper machine is equipped with a train of alternate non-metallic and cast-iron gears.

Each non-metallic gear is 6 ft. in diameter and the teeth are made in sections mounted on a metal spider

Using Non-Metallic Gear Drives

TO PREVENT NOISE

by eliminating the metal-to-metal tooth contacts and also

TO REDUCE GEAR WEAR

By **FRANK E. GOODING**
Associate Editor, Industrial Engineer

GEAR drives, particularly after they become worn or when they are improperly installed, often become noisy. Gear noises are particularly objectionable in that they are usually of a high pitch, which is very disagreeable when near offices or around women employees. Nervous or high-strung employees are affected by the high pitch and the resultant tension has been held as a contributary cause of many accidents. As gears wear they become noisy and wear more rapidly, which further increases the noise. This also decreases the effectiveness of the gear. With excessive wear comes increased vibration which creates undesirable operation.

While there is a natural wear on all metallic surfaces rubbing on each other, such as gear teeth, excessive wear and noise frequently are due to misalignment or improperly fitted gears. If the trouble is due to misalignment, the teeth will show uneven wear; that is, one end of the tooth will be worn more than the other. As a result part of the tooth is doing all the work and receiving all the wear, which under normal conditions should be distributed evenly over the length of the tooth. In such a case it is but natural that the wear will be very rapid, and trouble and noise begin.

If the teeth mesh too tightly into each other, the driving tooth rubs not only on the driven tooth but also on the next tooth. This action destroys the tooth contour and requires an excessive amount of power until the teeth are worn down so they no longer rub on both sides. Worn teeth always permit backlash,

which results in noisy and irregular operation.

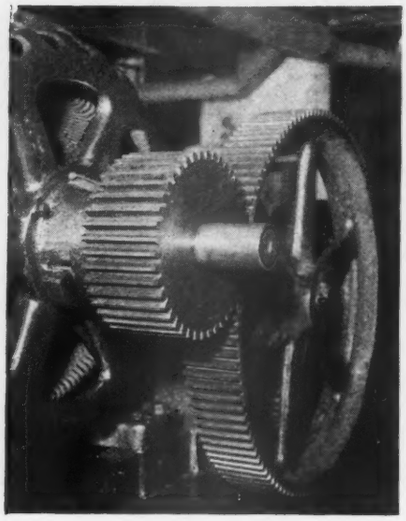
Where teeth do not mesh into each other far enough the load is carried on the ends of the teeth instead of on the pitch circle. This also results in uneven wear, with noise almost from the first when metallic gears are used, and considerable vibration which is undesirable from an operating standpoint.

When operating men find a metallic gear drive which wears excessively or becomes noisy rapidly, they should make a careful investigation of the alignment of the shaft and the meshing of the teeth. Correcting improper operating conditions will prevent a large proportion of the unusual wear of gear teeth and decrease the resultant noise of operation. These conditions should be remedied before non-metallic gears are installed or excessive wear will result, although perhaps not as quickly as before, even though the noise is not so obvious.

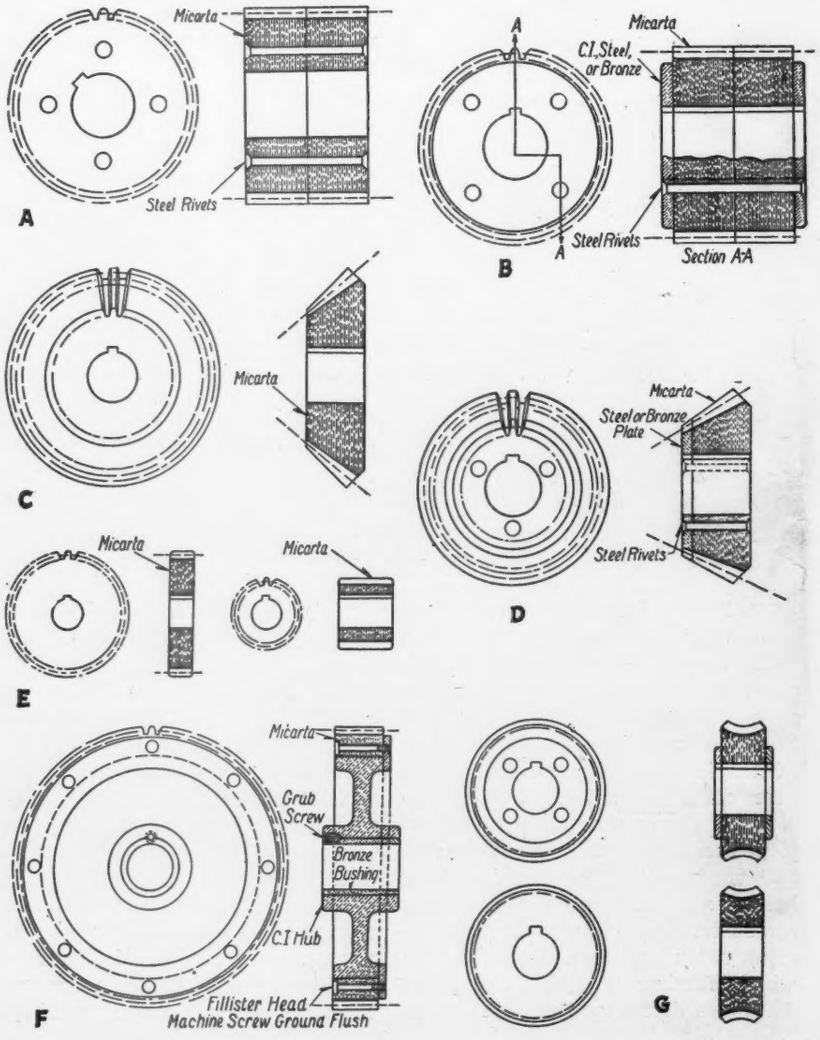
In studying the wear of gears, it has been found that less wear occurs if the meshing gears are not of the same hardness, which usually means that they should be of different material. This does not always mean that the pinion should be of a softer material, as hardened, alloy-steel pinions are used with a great deal of success in many industries where they are subjected to excessive wear. For silent gears, however, a non-metallic material softer than cast iron or steel (the materials from which gears are commonly made) is usually used. These non-metallic gears and gear materials will be discussed at length in this article.

It has been found that it is necessary to change the material in only one gear. As the pinion is the smaller, it is usually made of one of the substitute materials, all of which are more expensive than cast iron or steel. Of the non-metallic gear materials rawhide has been used the longest for industrial power transmission. Within the past few years a Bakelite-fabric product manufactured under various trade names, and a treated fabric product, both of which will be described later, have been used extensively.

In the manufacture of rawhide for gears steer and bull hides as well as the hide of the water buffalo of the Orient are used. Cow and calf hides are not suitable. These hides are dehaired and cleaned, then stretched and dried until they are hard and bonelike. The dried sides, as they are called, are somewhat thinner than the green hide and in drying are not "plumped" or thickened in the process by using a filler, as is possible when tanning a hide. Gear blanks which would be made from thickened hide do not contain as many layers per inch of width; consequently the life and strain-resisting qualities are considerably reduced. Rawhide can be made no stronger than the original fiber of the green hide. This strength is retained by proper curing. After the hides have been cured, they are cut



This non-metallic pinion on a 100-hp. motor drives a high-pressure pump.



Some of the types of standard construction which have been recommended and generally adopted for non-metallic gear and pinion construction.

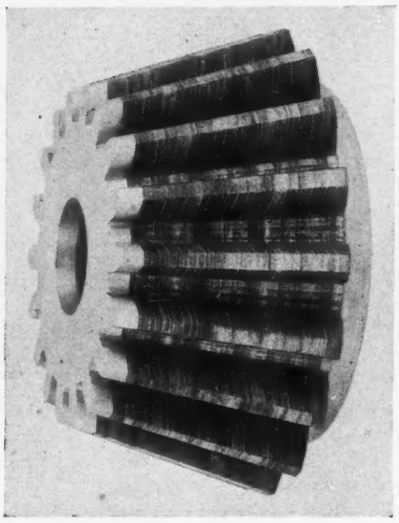
These sketches were prepared by the Westinghouse Electric & Mfg. Co., in connection with their Micarta gear material. The suggestions, however, are practically standard for all non-metallic Bakelite materials where the gear blank is cut from the board. *A*—Standard construction for riveted gear blank. *B*—Standard construction of pinion with endplate to give added hub strength. *C*—Non-metallic bevel gear. *D*—Non-metallic bevel gear with endplates to support keyway. *E*—Examples of standard construction for small pinions. *F*—Method of constructing large gears with metal hub and center and non-metallic material bolted to a flanged rim. *G*—Non-metallic worm gears with and without endplates.

into disks which are assembled in layers and cemented together to form blanks. The rough blanks are placed in a drying room which is kept at a fixed temperature. This drying process continues from two to three months, depending upon the size and thickness of the blank.

Before cutting the teeth in the gear blank, a metallic endplate, commonly of brass, is bolted or riveted through the blank. This endplate serves two purposes: First, it holds the ends of the teeth in shape and also provides a more substantial material for cutting the keyway in the pinion. For very quiet operation, it is desirable that this endplate be outside of the mesh of the gear and its pinion; that is, that no driving be done by the metallic portion.

Rawhide pinions will serve almost any class of machinery where a positive, quiet drive is an essential factor. They must be correctly aligned and properly made if satisfactory operation and long life are to be expected. However, their noiseless feature does not terminate even when they are badly worn. Also, their elasticity reduces vibration and prolongs the life of the mated metal gear. These qualities are common to all non-metallic gearing.

The manufacturers do not ordinarily recommend the use of rawhide pinions on machinery where they are applied directly to the transmission of severe reciprocating or intermittent motion, or in connection with cast gears. Cast gears are irregular and the rough gear teeth will wear the pinion excessively.



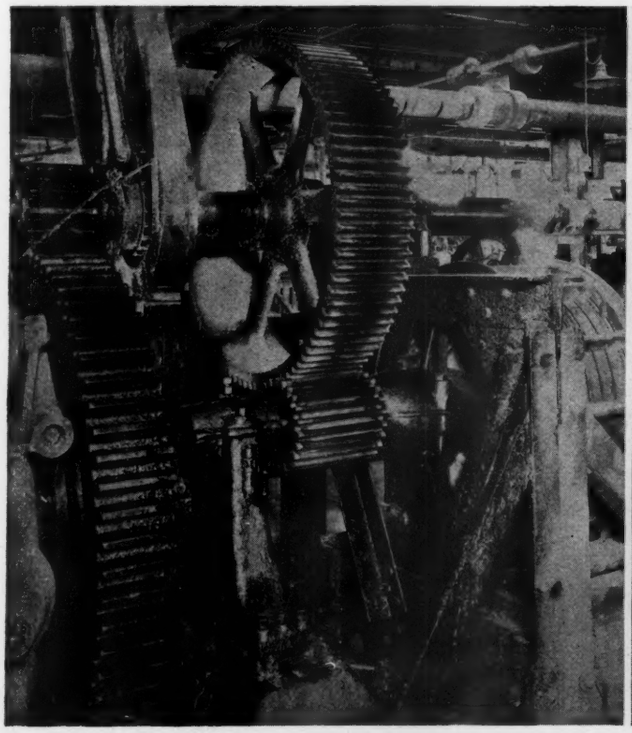
Construction of a rawhide bevel gear.

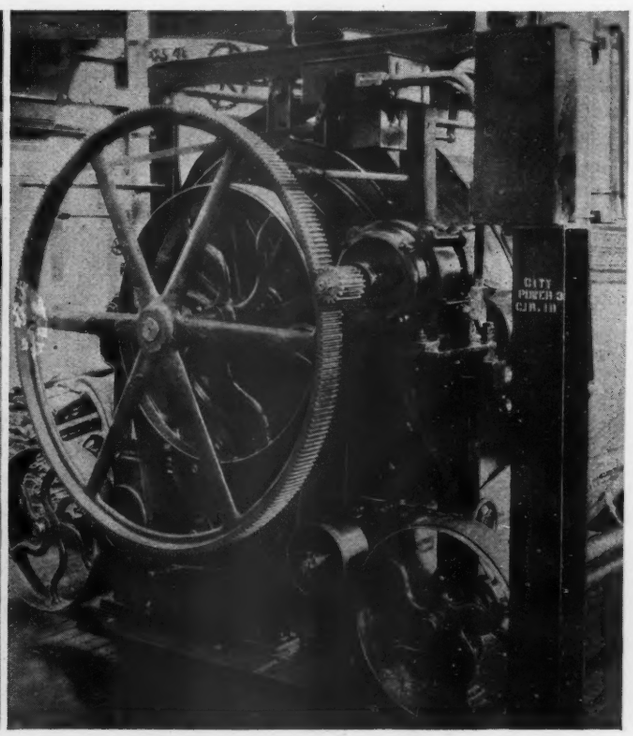
Rawhide gears are made up of layers of dried and seasoned hide, held together by endplates which are commonly made of brass.

Reversing under load or reciprocating and intermittent loads, require that extra large allowances be made in the gear teeth to take care of this extra load, because such loads cause a continual bending action which is not desirable for rawhide.

The rawhide pinion will stand considerable variation of temperature from extreme hot and dry to moist. Cold has no effect on rawhide, but it is not advisable to use rawhide pinions or any other non-metallic gear in an installation where the temperature is over about 200 deg. F. Also, rawhide pinions are not recommended for use where they will be continuously subjected to water or to a bath of oil. Rawhide pinions will stand occasional water and the amount of oil usually encountered on motor-driven machines, but if they are allowed to stand in water or oil the teeth will warp and lose their shape. When storing rawhide gears they must be protected from heat and moisture.

In rating the capacity it is estimated that a rawhide pinion will carry from 75 per cent to an equal load and the same strain as a cast-iron pinion of the same size and pitch of tooth. The non-metallic pinion does not have the breaking strength of steel, and often where the load is irregular and gears are subjected to vibration, the rawhide pinion will stand up better than the metal pinion because of its elasticity and the resulting ability to give un-





Each of these motor pinions is made of impregnated cotton fiber, compressed and bolted together between endplates under high pressure.

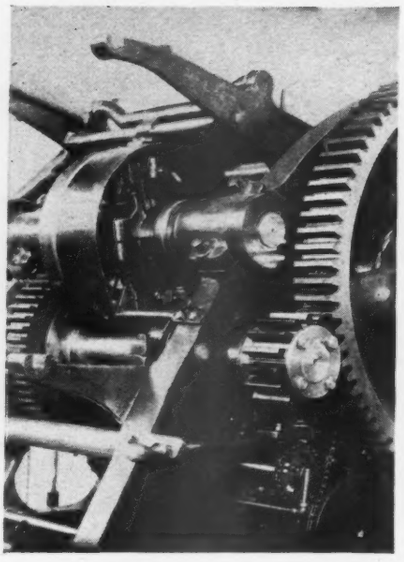
Where very quiet operation is desired, the endplates do not touch the metal gear; this makes the pinion wider than the gear. For ordinary operation the pinion and gear are of the same width. The illustration at the left shows a pinion drive to a double rubber sheeting mill. The pinion drive at the right is on a napping machine in a textile mill.

der an abnormal or unusual stress.

Manufacturers do not recommend the construction of a pinion with a hub and setscrew attached to one side of the flange or endplate because this throws an uneven strain on the rivets or studs holding the pinion together. Helical or herringbone rawhide pinions are not recommended for heavy service. They operate satisfactorily, however, on light, high-speed duty at a recommended angularity of from 15 to 20 deg., which gives continuous tooth action and avoids vibration. A pinion should not be made so small that there is not room for inserting the rivets to hold the layers of rawhide together. Steel or cast-iron endplates may be used on rawhide pinions, although this involves an extra cost over the brass endplates which are cut through to conform to shape of the teeth. Rawhide gears of extra large diameter are usually made by building up a rawhide face on a cast-iron spider. This decreases the amount of rawhide required and so makes them less expensive.

During recent years, considerable attention has been given to the use of chemically-prepared, non-metallic gear materials which consist generally of layers of fabric impregnated with and incorporated in, under heat and pressure, a body of Bakelite phenol resinoid. These materials are prepared by several companies under license of the Bakelite patents and are distributed under different, well-known trade names, such as Celoron, Contex, Fibroc, Formica, Micarta, Textolite, and others. Although all of these are made under the same basic patent which covers the method of impregnation, the fabric used and the method of handling and assembling differ to some extent among the different manufacturers. In every case Bakelite resinoid is the essential ingredient of the laminated material.

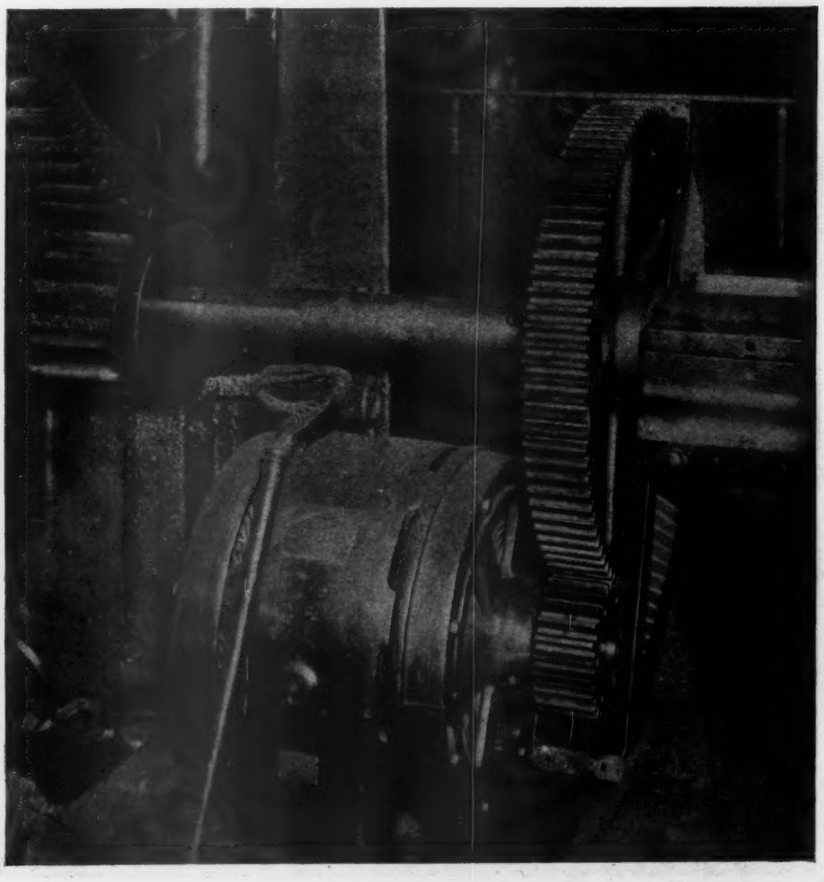
In the manufacture of these laminated, non-metallic materials, the initial resinoid is first dissolved in a suitable solvent to form a varnish. This varnish is used to impregnate the laminating fabric which is usually linen or canvas. The impregnating is done on machines through which the fabric is made to pass slowly. By a combination of rollers it is made to pass through a dip tank or other device by which the varnish is continuously applied until the fabric is uniformly coated and impregnated throughout. The varnish-laden fabric then passes through a drier for evaporating the solvents. When dried, the material is cut into prescribed dimensions and a number of such sheets are superimposed and put under heat and pressure. The resultant product is a hard, rigid plate or board.



Extra small pinions of non-metallic materials require special construction to give them the necessary strength.

Under the correct conditions of temperature and pressure, this mass of Bakelite-laden layers of fabric is completely transformed into a uniform board, which it is stated cannot be resoftened by heat, is not affected by water or oil, and only by comparatively few chemicals, possesses good dielectric properties, and has considerable mechanical strength, but is easily machined.

The method of building up the gear blanks from this laminated material differs somewhat among the various manufacturers. The more common methods used are as follows: The first and perhaps the most common method, is to cut the blanks from laminated board of a thickness equal to the gear face. These boards are put out by different manufacturers in sizes that vary somewhat but are approximately 40 x 40 in., and of different thicknesses. The



This 10-hp. motor drives a boring mill through a Bakelite laminated pinion.

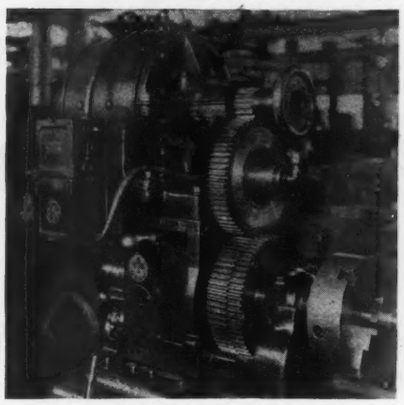
Here the high-speed motor pinion is made of a non-metallic, noiseless gear material while the slower speed pinion in the backgear driving the mill is made of cast iron with shrouds. The manufacturers never recommend the use of non-metallic pinions or gears driving in contact with cast gear teeth because of the latter's irregularity and rough surfaces which cut the non-metallic material.

blank is a single piece of material and may be cut out from the original board with a band saw or by other means.

Another method is to cut the blank out from the individual coated and impregnated sheets of fabric and then axially stagger these round sheets when stacking them to obtain the proper face thickness. This staggering of the warp and woof lines of the fabric utilizes its bias strength and permits the application of a higher horsepower rating per inch of face than is possible with gears cut from boards, according to the manufacturer. This stacking of the die-cut sheets is done before the heat and pressure are applied to transform the Bakelite. These die-formed blanks, it is said, are particularly adapted to the requirements of manufacturers who machine their gears in quantity as the size of the blanks is such so as to eliminate the waste incurred when cutting the blanks from boards.

There is still another method of making a fabric-base, non-metallic gear material which does not use the Bakelite resinoid process. This gear is made of an impregnated cotton fiber. Originally this gear was made of layers of cloth, assembled between steel end plates, compressed and fastened together with studs. The teeth were then cut. The result was a cloth gear which was, in general appearance and method of assembly, very similar to a rawhide gear.

At present, instead of using cloth, cotton fiber in the form of a batting is compressed into thin sheets and disks are die-cut from these sheets



Here a non-metallic gear is used as an idler between the metallic motor pinion and the gear in the head of the lathe.

to the required diameter. A number of these disks, depending upon the desired gear face, are assembled in steel tubes, between steel endplates and compressed at about 8 tons per sq.in. While under compression holes are drilled and tapped and studs are screwed through the entire structure of endplates and fabric, thus holding the gear blank in permanent compression. These blanks are then put through a certain process in which they are subjected to heat and high vacuum, so that air and moisture are removed. This is followed by an oil impregnation which renders the cotton fiber impervious to water and oil and unaffected by heat or cold.

The manufacturers of these materials state that their power transmission ratings should be from 75 per cent of the rating of a corresponding cut cast-iron pinion or gear of the same pitch and face to a ratio of 1 to 1 or better. The American Association of Gear Manufacturers recently adopted the recommendation that all non-metallic gears be estimated on a basis of three-quarters the rating of a corresponding cast-iron gear.

The permissible rating of a gear should be influenced by the service conditions in the same way as any other item of mechanical power transmission equipment. For example, the maximum load should be considered always and in case of a motor drive an allowance made for at least 50 per cent overload. Where the duty involves the starting of heavy loads or frequent reversals under load, an allowance of 100 per cent overload should be made.

In estimating the capacity of a non-metallic gear, it is difficult to make a direct comparison between the strength of the non-metallic and the metallic materials. For example, the accepted standard fiber stress value for these non-metallic materials is 6,000 lb. per sq.in. (with higher rating for specially-prepared products) as compared to 8,000 lb. per sq.in. for cast iron, 12,000-15,000 lb. for cast steel, and 15,000 up to 35,000 lb. or more for steel, depending upon the composition and heat-treatment.

The manufacturers of non-metallic gear materials do not consider it reasonable to compare the rating of their products according to these stress values. This is for two reasons. First, the treated, alloy-steel pinion driving the cast-iron gear is considerably stronger than its mate, and so a gear to replace it would not need the same high strength. The treated steel gear is used because of its wearing qualities, rather than its strength. Also, the non-metallic materials have a resiliency that does not exist in metals and this factor aids the non-metallic material to meet an impact load without the probability of fracture that might be present in a more brittle, or rather in a less resilient, material. It is stated that the safe working load of the non-metallic material does not decrease with increased speed of the gears nearly as rapidly as does the safe working load value of the metal gear-tooth. Much experimental work is being carried on at present to

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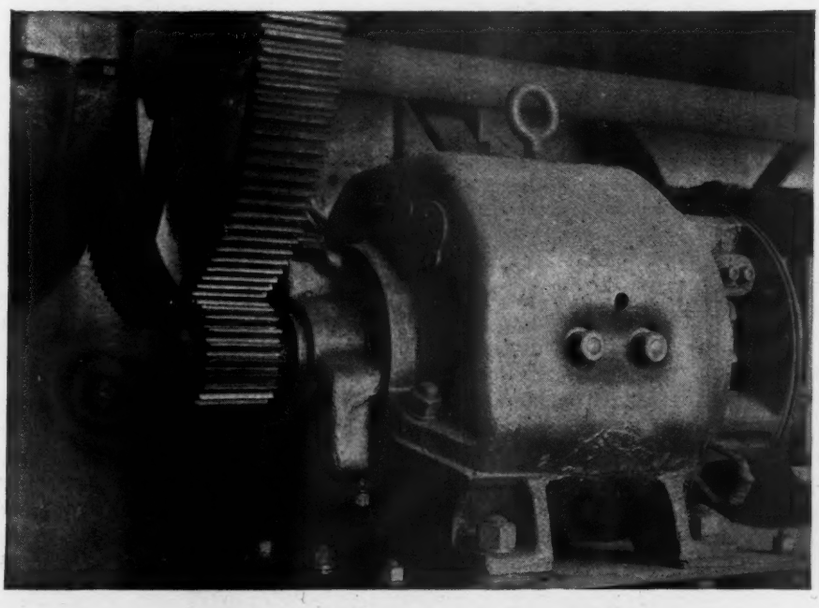
In this drive a non-metallic pinion is mounted on a 5-hp. crane bridge motor.



Controlling Power Input to Wood Pulp Grinders

by special electrical regulating devices that are applied to the continuous feed of synchronous-motor-driven magazine grinders

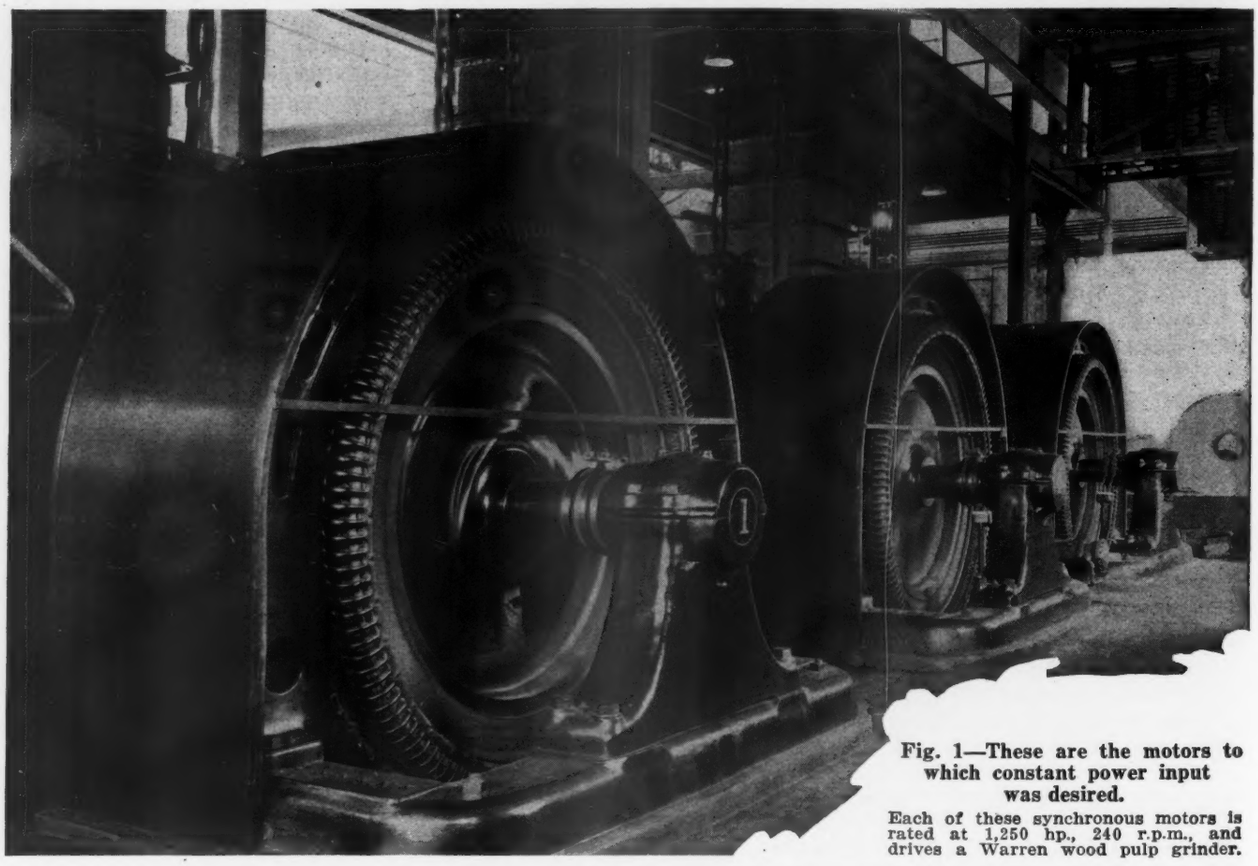


Fig. 1—These are the motors to which constant power input was desired.

Each of these synchronous motors is rated at 1,250 hp., 240 r.p.m., and drives a Warren wood pulp grinder.

By F. A. BYLES

Flow Meter and Regulator Engineering Dept., General Electric Co., Schenectady, N. Y.

THE tremendous increase in the demand for high-grade wood pulp in the paper industry of this country brought about the development of a wood pulp grinder of large capacity. The continuous-feed, magazine grinder of the Warren type was developed to fill this need, and with its development came the problem of load regulation. This type of grinder is usually driven by a synchronous motor and, in order to obtain a long-fiber, high-grade pulp it is necessary to keep the power input to the grinder at a steady value.

The installation recently made by the Iroquois Pulp and Paper Company, Thompson, N. Y., is a good example of modern methods of grinder regulation. This installation is of the single-grinder type (one stone driven by one motor), the regulating and control system being considerably less complicated than that used when two grinders are driven by one motor, although the general scheme of regulation for this latter method is the same except that additional control apparatus is necessary to allow one or the other of the wood-feed motors to be stopped and the load automatically reduced to one-half.

In Fig. 1 are shown three synchronous motors, each of which is coupled to a Warren magazine grinder. Each motor is rated at 1,250 hp., 240 r.p.m., 2,200 volts.

The grinders themselves are shown in Fig. 5. From the floor above the wood is placed in the vertical magazine and is fed down against the grinder stone by four toothed chains which are operated by the series motor *A* shown in Fig. 6.

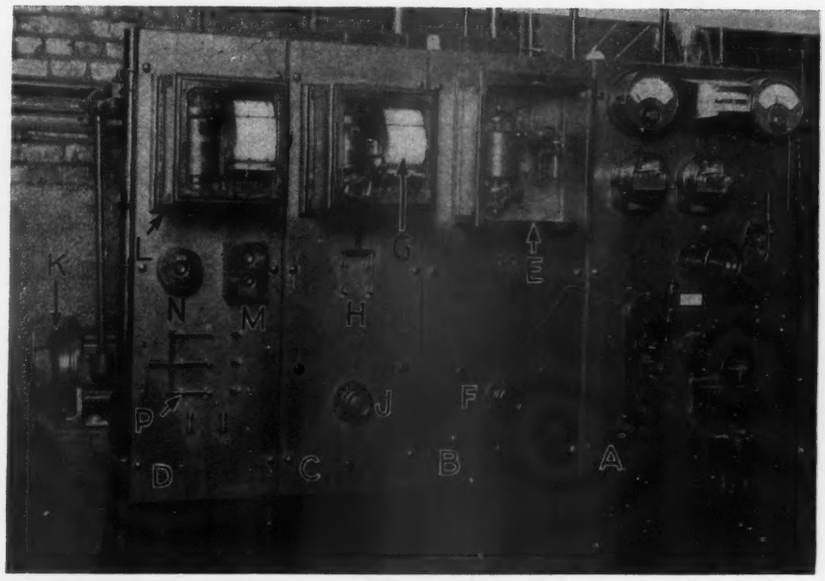


Fig. 2—These panels control the motor shown at (A) in Fig. 6 so as to insure a constant load on the synchronous motor (shown in Fig. 1) driving the grinder.

This motor is connected to the chains by means of a series of worm gear reductions, so that the actual chain feed is only a few inches per minute.

The speed of the grinder feed motor determines the power taken by the main synchronous motor and, by adopting a suitable regulator, the power input is kept at a steady value.

One of the combined control and regulator panels is shown in Fig. 2. The right-hand panel *A* provides for starting, stopping and controlling one of the 1,250-hp. synchronous motors. Panel *B* supports the load regulator *E* and its rheostat *F*. The curve-drawing wattmeter *G* on panel *C* records the regulated load. Switch *H* provides a means for disconnecting the control circuit which, in this instance, is 125 volts, and is supplied by the exciter which furnishes excitation for the three synchronous motors.

The rheostat at *J* provides a means for hand control when desired and is connected in series with the shunt field circuit of the d.c. generator which furnishes power for the grinder feed motor. The induction motor *K*, which drives this generator is shown behind the switchboard, mounted on a substantial concrete base. The curve-drawing ammeter *L* mounted at the upper end of panel *D* charts the current input to the grinder feed motor. An inspection of the current curve with respect to the power input curve enables the operator to determine the grinder performance to a very close degree. Push-button station *M* provides a means for starting and stopping the motor-generator *K*. Push button *N* is connected in the undervoltage release circuit of the main circuit breaker in the synchronous motor feed line, and provides a means for instantly disconnecting this motor from the line when so desired. Switch *P* provides a means for reversing the grinder feed motor when it becomes necessary to back up the wood in case of uneven grinding, or to remove the pressure from the stone.

When in operation a continuous supply of logs varying from 4 to 10 in. in diameter is fed down against the grinder stone. Streams of water playing on the stone prevent excessive heating and carry away the ground pulp-wood to the storage tank.

The general scheme of connections for the regulator is shown in Fig. 4. The switching and hand control apparatus has been omitted from this diagram for the sake of simplicity.

With reference to this diagram, the basic principle of operation is that of automatically controlling the shunt field of the d.c. generator which furnishes power for operating the grinder feed motor, so that constant power input to the main grinder motor will be obtained.

The main control element of the regulator is of the wattmeter type. The potential coils P_1, and P_2, which are connected to two potential transformers, are mounted on the pivoted center shaft and are arranged within, and at right angles to, the current coils C_1 and C_2. The current coils are connected to two current transformers in the line feeding the synchronous motor driving the grinder that is to be controlled. The torque produced by these coils is balanced against a pair of spiral springs. Load adjustment is obtained by spring S_1. The main control contacts (actuated by an arm connected to the shaft) are connected so as to open and close a circuit across the windings of relay *R*, which are connected to the 125-volt exciter busbars through resistance R_4. This relay causes a rocker arm to move over a series of contacts which in turn are connected to sections of resistance in series with the shunt field of the d.c. generator. When this rocker arm is in

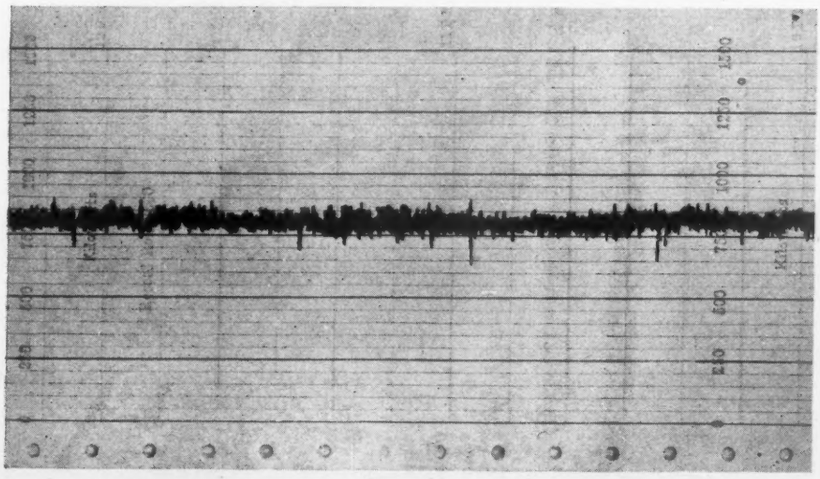


Fig. 3—This graphic meter record is from the recording wattmeter measuring power input to one synchronous motor.

The close regulation of the power input to the motor may readily be seen.

the extreme forward position *1* the resistance is entirely cut out and the highest generator voltage is obtained; when it is in the extreme backward position *2* the resistance is entirely cut in, which gives the minimum voltage.

Armature *A* of relay *R* shown in Fig. 4 is connected to the plunger of the dashpot by means of springs S_3 and S_4 in such manner that it floats between them. This allows the armature to travel a very short distance without moving the dashpot plunger (which moves in heavy oil), thereby obtaining very rapid contact action between the rocker contact and two or three of the stationary contact bars. When it becomes necessary for the rocker arm to take up a new position, a sustained pull or release on armature *A* causes the spring S_2 to come into action and allows the dashpot plunger to rise or fall giving the rocker an entirely new field of action.

The cycle of operation is as follows: The torque of the main control element increases as the load comes on until a balance is obtained between it and the spring mechanism. At this point the contacts operate the relay magnet, which in turn cuts in resistance in the generator field circuit, causing a lower generator voltage and a slower speed of the grinder feed motors. The lower speed of the feed motor causes the grinder motor load to be reduced slightly. This load reduction at once reverses the regulator operation by causing the relay rocker arm to rock in the opposite direction, cutting out a little generator field resistance, thus raising its voltage and the speed of the feed motors. This action causes the grinder motor load to rise slightly and the cycle is repeated. When in actual operation the contact action is rapid. The relay rocker arm takes up its position by rolling forward or backward as determined by the main control contacts until its regulating position is established, when it vibrates between two or three contact bars until the load requirements again cause it to take a new position of vibration.

The load curve illustrated in Fig. 3 shows the regulated load of one of these grinder motors when in actual service.

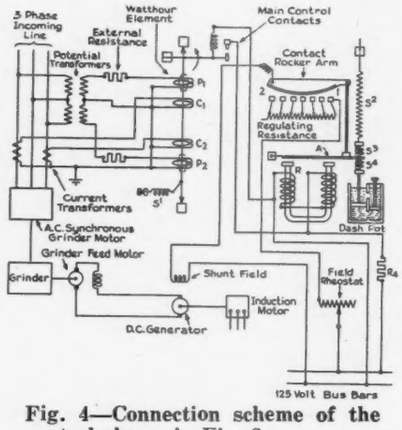


Fig. 4—Connection scheme of the control shown in Fig. 2.

Figs. 5 and 6—Wood pulp grinders at plant of Iroquois Pulp and Paper Co. to which automatic load regulation was applied.

At the left is shown one of the three Warren pulp grinders with its driving motor to the right. The four vertical chains feed the wood against the grinder stone. These chains are driven by motor *A* in the close-up view of the grinder shown in the illustration at the right.

Unusual Cause of Transformer Failure

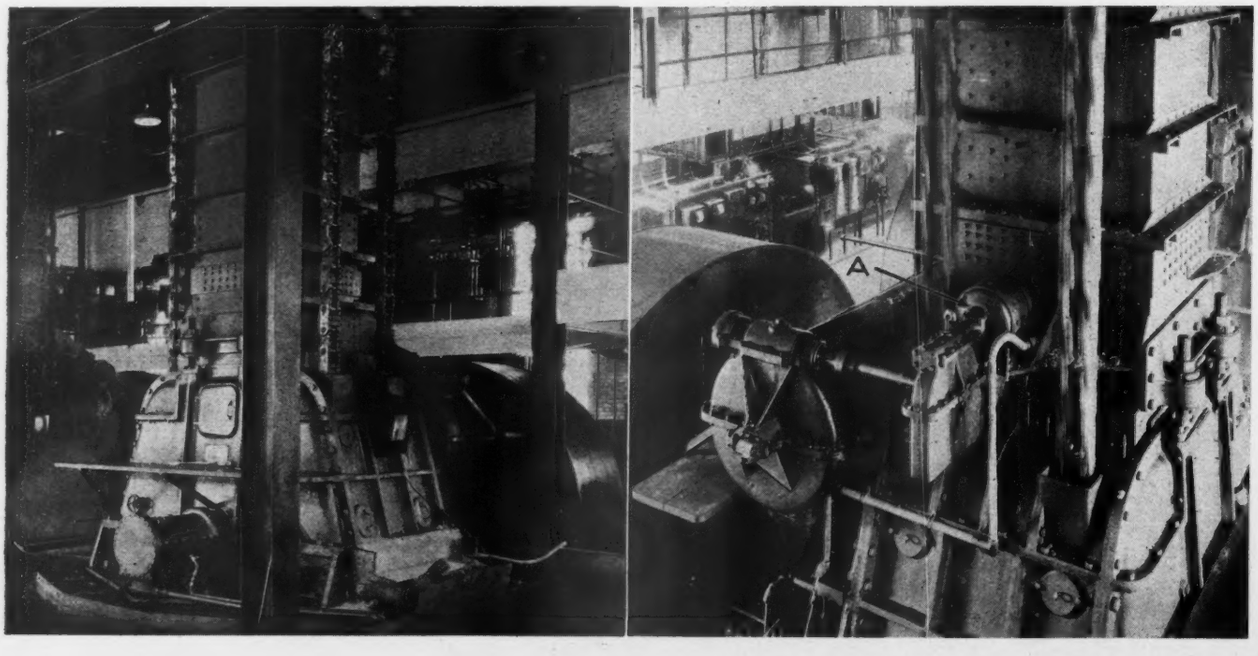
A CUSTOMER recently returned to the manufacturer some samples of oil taken from a transformer which had failed. The oil had been found dirty, and seemed to carry a large amount of black sediment for which the customer could not account.

Analysis of the oil showed small quantities of aluminum, for which the laboratory could give no explanation. The findings were reported to the customer, with a request for a possible explanation of the aluminum.

The matter was cleared up in a letter which read:

"The surprising results, which you have found, showing aluminum in the oil, are undoubtedly due to the fact that we painted the transformer tanks in the building with aluminum paint, using a paint spray. This no doubt saturated the atmosphere in the building with aluminum powder which was taken into the transformers through the breathers.

"This analysis has, therefore, given us a very valuable suggestion, and in the future we will see to it that the breathers are closed when aluminum paint, or any paint with a spray is used."



Selecting Commutator Mica

for Direct Current Motors

THIS, the first of a series of articles on commutators, takes up the selection, use and installation of mica as used in commutators of industrial motors. The second article of the series will discuss the subject of commutator bars while the third will tell how to assemble them. These articles will appear in early issues.

By JESSE M. ZIMMERMAN

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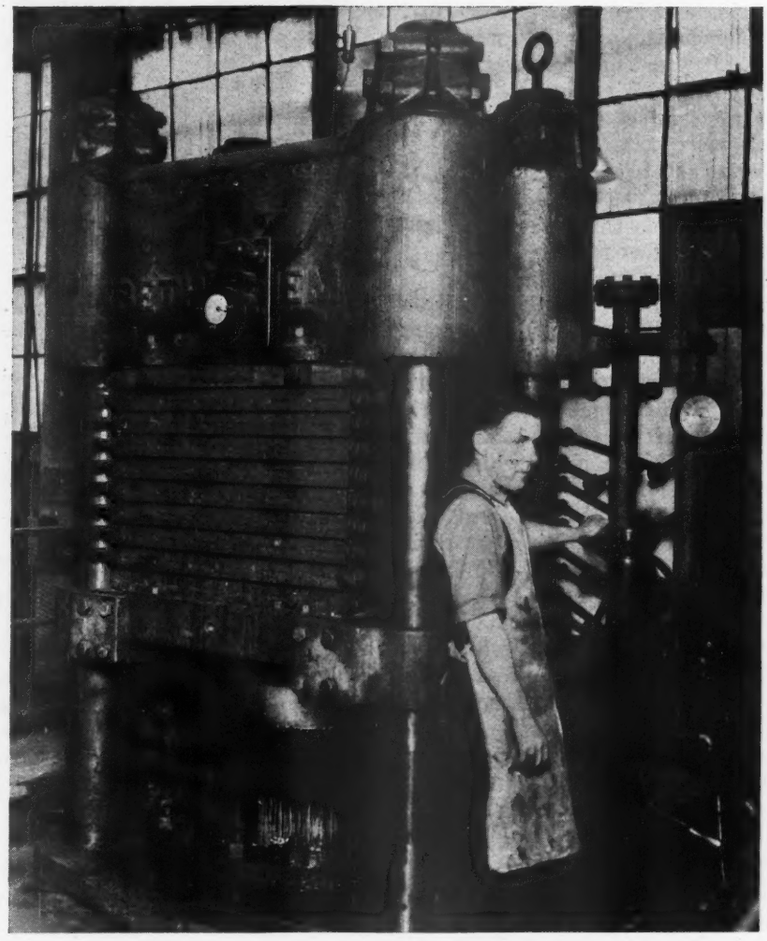
Westinghouse Electric & Mfg. Company
Pittsburgh, Pa.

IN BRIEF, a commutator is a mechanical means for converting the alternating current in the rotating armature of a generator to a continuous current which is to be supplied to an external circuit. In the case of a motor, the commutator takes the continuous current from the external circuit and delivers it to the armature coils, in such a manner that it will flow in alternate directions as the coils are forced alternately through fields of different polarity. These functions are accomplished by having the armature coils connected to copper segments, which are separately insulated and mechanically sustained, so that they alternately come in contact with a set of positive and negative brushes which are connected to the external circuit.

To the average user the theoretical principles of commutation mean but little. He is interested mainly in how the commutator is mechanically designed, why it was so designed and how can it best be maintained. Therefore, the writer will dwell in this series of articles upon the history and evolution of the commutator, the difficulties experienced along the path of progress, the present-day practice in manufacture of commutators and maintenance and repair of commutators, so as to assist in better understanding of proper commutator maintenance and to serve as a guide for purchasing renewals for repairing the same.



Steam-heated hydraulic press used for pressing commutator mica plate.
Great care is taken during the pressing operation to insure uniform density. Special pads are placed between plates in the press to obtain this result.

In the early days of motor manufacture some difficulty was experienced with the operation of large-sized commutators when the motors were placed on test and later in service, due to high bars appearing in them. It was necessary to dismantle the motor, tighten the commutator and re-surface the brush face before the motor could be put in service. Sometimes this operation had to be done several times. The unfortunate part of the situation was that this so-called seasoning operation had to be continued after the motor had been in service a few months. At the slightest indication of high bars the motor had to be dismantled. This led to a wide research to investigate different insulating materials as well as ways and means of providing a better mechanical structure.

In the early commutators, the mica strips were made of mica plate having a high bond content. Although the plate was made of high-grade mica splittings the methods of making mica plate were less advanced. The commutators were made arch-bound and while the commutator was going through the seasoning period, the bond would ooze out from between the bars. This caused the mica to shrink, relieving the arch-binding between the bars because the seasoning process did not completely harden the bond. In fact the bond continued to ooze out when the motor went into operation. Due to centrifugal force the bars rose where the bond oozed out excessively, thereby causing high bars. It is evident then that one of the difficulties was due to the

mica strips used in the construction of these commutators.

A search was then made for an insulating strip which would be more adapted to commutator service. Asbestos and fishpaper were two of the numerous insulating materials tried. It was found, however, that a mica plate with a low bond content and properly seasoned was superior to all other materials tried.

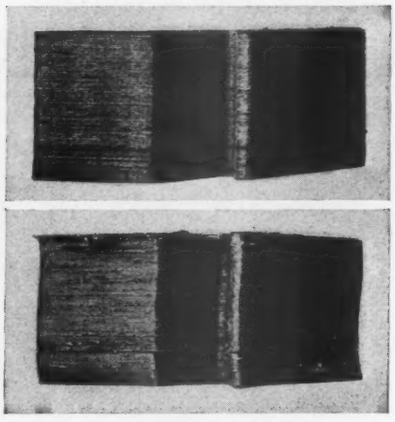
There are two different types of mica splittings used in present day industrial commutators, namely white and amber mica splittings.

White mica splittings known as hard mica come from mines in India and are capable of standing a very high temperature before decomposing. Use of this material, however, is limited to commutators which are undercut. If the commutators were not undercut, the mica, which does not wear as rapidly as the copper, would permit the brushes to ride on the mica thus causing a very rapid burning action between the brush and the commutator surface that is very injurious.

Amber mica splittings which are soft and more easily compressed than white mica are mined in Canada and East Africa. This soft quality makes them more adaptable for commutator use because the mica segments will wear away as rapidly as the copper thus eliminating the necessity of undercutting. This is an advantage for there are some applications of direct-current motors where undercut commutators are undesirable. This is particularly true in textile mills where the lint collects between bars of an undercut commutator and carbonizes thereby causing a short. Wood pulp and paper mills provide similar examples. For such applications as these the amber mica is desirable despite the extra cost.

It is well to carefully ascertain whether renewal commutators have segments containing amber or white mica. Very often the difference in price which may exist between two bidders, can be explained by the fact that one will furnish amber mica while the other will furnish white mica.

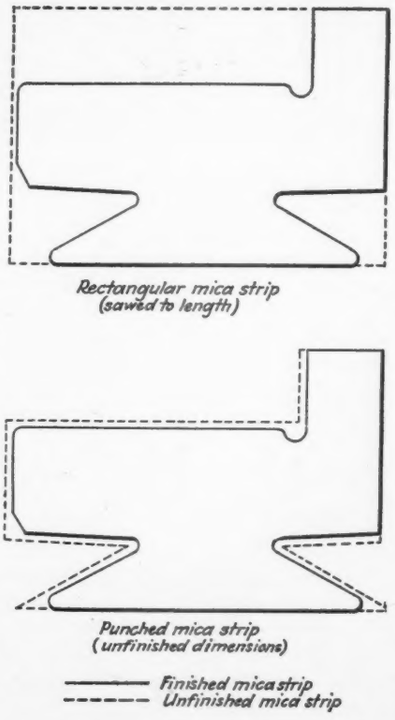
The process of making mica plate from the two different kinds of splittings is the same. It is necessary that the splittings be free from clay spots, metallic spots, cross grain, heavy edges and heavy pieces. The splittings are usually about one mil thick and are held together by a minimum amount of dry bond which will flow at a medium temperature.



Results of tests made on commutator mica to determine whether the bond was properly seasoned.

These two illustrations show two sets of mica strips after having been heated and pressed under identical conditions. The top illustration shows strips in which the bond was properly seasoned and the slippage of mica and oozing of bond negligible. In the bottom illustration there are visible signs of slippage of mica and oozing of bond indicating that the bond was not properly seasoned.

Use of the "dry method" of making mica plate permits the use of a bond which does not contain alcohol as a solvent. Alcohol as a solvent is dangerous because it does not completely evaporate. When mica plate containing alcohol is used in a commutator, the alcohol may evaporate and migrate to some part of the commutator and condense. This sometimes occurs at the point of the V's producing a weak spot in this location. Great care is taken during the pressing operation to insure uniform density as shown in the illustration at bottom of page 560. Special pads are placed between plates in the press to obtain this result as is shown in the illustration of the steam heated hydraulic press on page 557.



Rectangular pieces of mica are more economical for small lots of segments.

To insure as little waste as possible the bars should be placed on the mica strips as shown. They may be shellacked to the strip, after which the segments are cut apart and trimmed to size.

The mica plate must pass through a seasoning operation which serves to make the bond infusible. After the seasoning operation, the mica plate is milled with an allowable variation of plus or minus 0.001 in. If the variation exceeds this value, the distance from any bar to the corresponding bar under the next pole may vary more than plus or minus $\frac{1}{32}$ in. Some manufacturers of mica plate only pass the plate through a sanding machine and do not machine it, thereby resulting in a plate thickness that is not within the allowable variation. One can distinguish this type of plate by the marks of sand rolls.

Mica plate will compress a certain amount when the assembled segments are heated and drawn tight with the clamping ring. This compression factor must be taken into consideration when milling the mica plate.

Every sheet of finished mica plate should have a surface coat of pure orange shellac. This treatment has the following advantages: (1) It prevents flaking and scaling of the mica splittings in handling and storage. (2) It keeps the mica plate free from dirt and moisture while in storage. (3) It tends to reduce oil and moisture absorption when the commutator is in service. The shellac cements the adjacent bars to the mica strip, thus reducing the creepage of oil and moisture along the copper bar. (4) It facilitates assembling. By heating segments before the V's are machined, the shellac glues the segments together. Therefore, when the banding wire is cut, they remain in a firm body and will not fall apart. This makes it possible to assemble the parts of a V-bound commutator without skewing the bars.

Mica plate should not absorb more than three-fourths of one per cent of its own weight of oil when placed

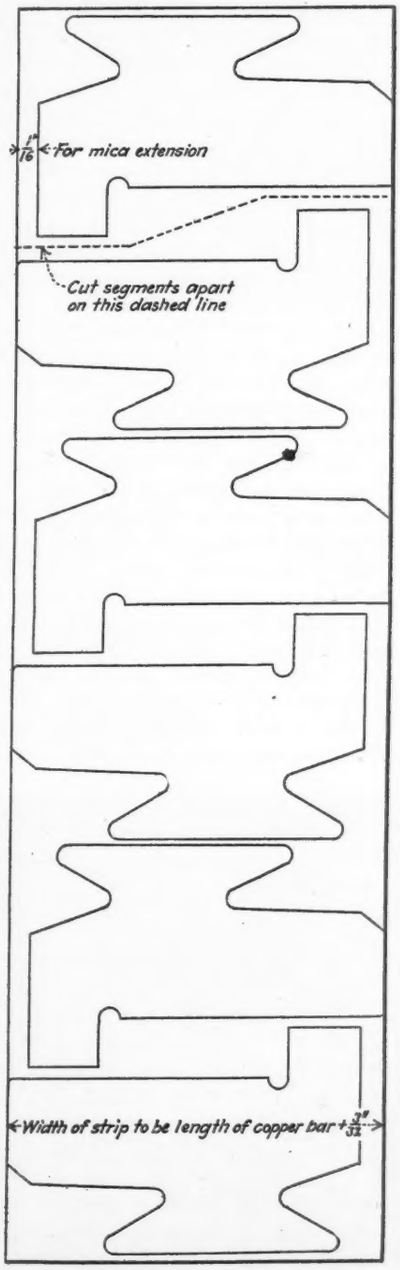
between two commutator bars under working pressure and immersed in oil for 24 hr. The oil absorption quality of mica is dependent upon the amount and quality of bond. Unless the entire surface of every splitting is covered with bond, oil getting on the commutator will find its way into the mica plate lodging between these splittings. Therefore, it is just as essential that the finished mica plate have a sufficient amount of bond to prevent oil absorption as it is for it not to have an excess amount of bond which will ooze out when the commutator is in service.

Mica plate should be able to stand a pressure of 10,000 lb. per sq.in. when heated to 150 deg. C. without showing slippage of mica or oozing of bond. Slippage of mica and oozing of bond are due to excess of bond which has not been properly seasoned. It is very important, then, that all commutators and more especially the arch-bound commutator should be made of a mica plate which has the bond properly seasoned.

A good means for testing mica strips, to determine whether the bond has been properly seasoned, is to place a dozen strips between two parallel steel bars which have a bolt at each end to exert a clamping action. The steel bars should be strong enough so that they will not bend. After the strips have been placed between the bars, tighten the nuts with a "trip wrench" and measure their thickness. Place them where they can be heated to at least 150 deg. C. but do not allow a flame to strike the strips as it will consume the bond. When they are thoroughly heated again tighten the nuts with the same "trip wrench" and allow to cool. Once more measure the thickness of the assembled strips to determine the amount of compression. Absence of slippage of mica or oozing of bond is an indication that the bond was properly seasoned. If the bond squeezed out, the strips should not be used in a commutator.

Photographs were taken to show two groups of mica strips after they had been under identical tests as described in the foregoing. The illustration at the top of page 558 shows no effect due to compression because the bond was properly seasoned. The bottom illustration, however, shows the slippage of mica and the oozing of the bond. This clearly illustrates how the two types of mica plate will act after they have been in the commutator. It would be well for operators to give the above outlined test to a sample of the mica plate which is to be used for repairing commutators.

The question of how to order mica strips for repairing commutators has been asked by many maintenance men. The manufacturer of the original commutator will supply mica strips in one of two ways: namely, (1) Punched to an unfinished size, and (2) rectangular mica strips.



Mica strips punched to an unfinished size are more economical if many strips of a given size are required.

The copper bar is shellacked to the strip as shown and the strip trimmed to size and V's cut by means of a knife and knife file.

When the V's and necks of the copper bars are punched for manufacturing purposes, the mica will be punched in the same manner. This mica die will leave 1/32 in. of material on each side of the V for finishing purposes. This is shown in the illustration at the bottom of page 558.

When the mica strips are received in this form, they can be finished very easily by pasting the strip to the copper bar with shellac. When the shellac is dry, place the two in a vise with the mica strip toward you and cut the V's to the same size as the copper V's. Be sure that the stroke of the knife is toward the copper. In this manner the mica will cut without tearing. It may be necessary to take a finishing cut with a knife file. Handle the file in the same manner as the knife.

When there are only a few commutators of a given size, it does not pay to make a die for punching the V's and necks in the rough, for it is cheaper to make the commutator from the rectangular copper bars and mica strips than to make a set of punching dies. Where this condition exists, the mica strips will be rectangular for repair purposes.

When rectangular mica strips are received, it is best to paste them to the bar with which they will be used. Cut the V in the same manner as mentioned in the forgoing.

When a complete commutator is to be refilled a set of mica strips will be required. Some repair men do not care to use the mica in either of the above mentioned forms because it requires too large a stock to take care of such a varied line of motors as is usually found in the average industrial plant. Under these conditions it will only be necessary to carry the mica plate in sheet form for the three standard thicknesses.

By careful consideration the amount of scrap can be kept to a minimum by the following method:

Assume that the copper bars (finished) are 5¾ in. x 3 in. If the sheet is 24 in. x 36 in., it can be cut into six pieces 6 in. wide and 24 in. long.

Apply a coat of pure heavy orange shellac sparingly on the one side of each piece. Lay the copper bars on the shellacked side in the manner shown in the drawing on this page. It will be possible to get eight mica strips out of each piece.

If a rear mica extension is desired, lay the bars on the plate so that there will be 1/32 in. of mica extending from the rear of the bar. This mica

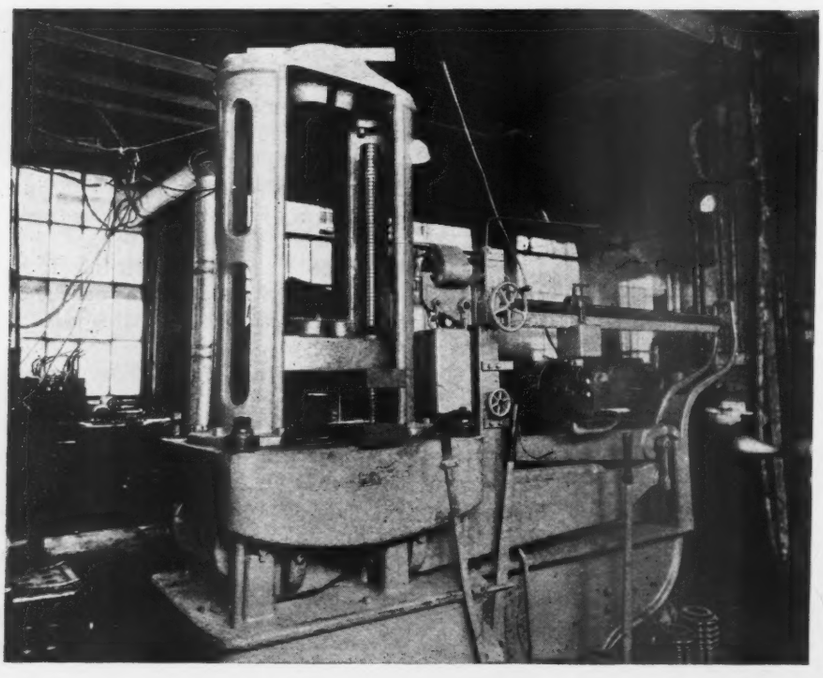
which extends in the front can be removed by the machine tool after the commutator has been assembled or with a knife when the V's are finished.

After the shellac dries, saw the strips apart (as shown by the dashed line) with a band saw if one is available. If a band saw is not available they can be cut apart with a coping saw. If a coping saw is used a piece of fuller board should be placed in the vise so that the edge is even with the place where the mica plate is to be cut. Care should be taken so that the stroke of the saw will be toward this piece of fullerboard in order to prevent flaking of the mica. If a band saw is used, the set of the saw should be small and the throat in the table for the saw to pass through should be very narrow.

After the strips have been cut apart, the V's can be sawed out with the band saw or cut out with a knife. It may be necessary to take a finishing cut with a knife file before assembling.

After the V's have been finished, do not remove the mica strips from the copper bars but assemble them while they are stuck together. After the commutator has been assembled cold, align the bars properly. Heat the commutator to a temperature of 125 deg. to 150 deg. C. and tighten while under pressure. The assembly of commutators will be treated in detail in the third article of this series. The second article, which will appear in an early issue, will discuss the selection of copper as used in making commutator segments.

Special testing machine used for measuring the density of commutator mica strips.



Lamp Protection Necessary in Atmosphere of Explosive Dust

IN AN article on safe lighting equipment for dusty locations, published in *Chemical and Metallurgical Engineering*, Kirk M. Reid, Engineering Dept., National Lamp Works of General Electric Co., stated that extensive tests have been made by the National Lamp Works, to determine what hazard is involved in the use of incandescent lamps in atmospheres containing explosive or inflammable dust.

Tests made by the Government have shown that nearly all finely-divided dust, if combined with the right proportion of air, will explode or ignite when brought in contact with an open flame. It has also been demonstrated that such dusts may be exploded by static electricity, by the electric arc from a short-circuit or a loose connection in a lamp socket, or by contact with the white-hot filament of either a vacuum or a gas-filled lamp. The National Lamp Works tests have proved that the hazard due to bulb breakage is not confined to the gas-filled lamps. Any vacuum lamp, except possibly extremely low-wattage lamps, such as the 10-watt and the 15-watt, will ignite an explosive dust cloud if the glass bulb is cracked or shattered.

A number of tests have also been made to determine the smoking and ignition temperatures of various dusts which are commonly found. These temperatures, when compared with the temperatures of different sizes of modern vacuum and gas-filled lamps, indicate that there is a reasonable margin of safety, in most cases 150 deg. or more. No trouble was experienced in making the dusts smoke and char, but they could not be made to ignite even when packed tightly around the lamp bulb. However, when dust accumulates on a lamp bulb and is successively heated and cooled as the lamp is turned on and off during a long period of time, the dust changes to a hard crust whose temperature may be raised to the danger point.

In considering what protective measures are necessary for incandescent lamps in atmospheres of explosive dust, it does not make much difference whether the hazard arises from the accumulation of dust on the bare lamp bulb, as is commonly supposed, or whether the real danger lies in breakage of the bulb, as the tests indicate. In either case the answer is that all incandescent lamps, vacuum and gas-filled, except those of the lowest wattages, should be protected. Under ordinary conditions, with free circulation of air around the lamp bulb, it is not likely that a fire will be started readily by vacuum lamps of small or medium size, but it is well to be on the safe side and equip them with heavy wire guards, at least. The larger vacuum lamps, such as the 100-watt, have heavier filaments which retain their heat for a relatively long time and thereby constitute a hazard in case of bulb breakage. Hence, in view of present knowledge on the subject, it is clearly unsafe to use bare, unprotected vacuum lamps of the larger sizes, in atmospheres containing explosive dusts. It is not sufficient to equip these large vacuum lamps with wire guards only; unless they are enclosed in dust-tight or vaporproof lighting units they are definitely dangerous.

Where the lighting units employed are subject to breakage by being struck it is well to take the additional precaution of supplying heavy wire guards. Also, under extremely hazardous conditions, such as arise from the presence of highly-explosive vapor in the air, it is safer to supply the artificial lighting from sources entirely outside of the room.

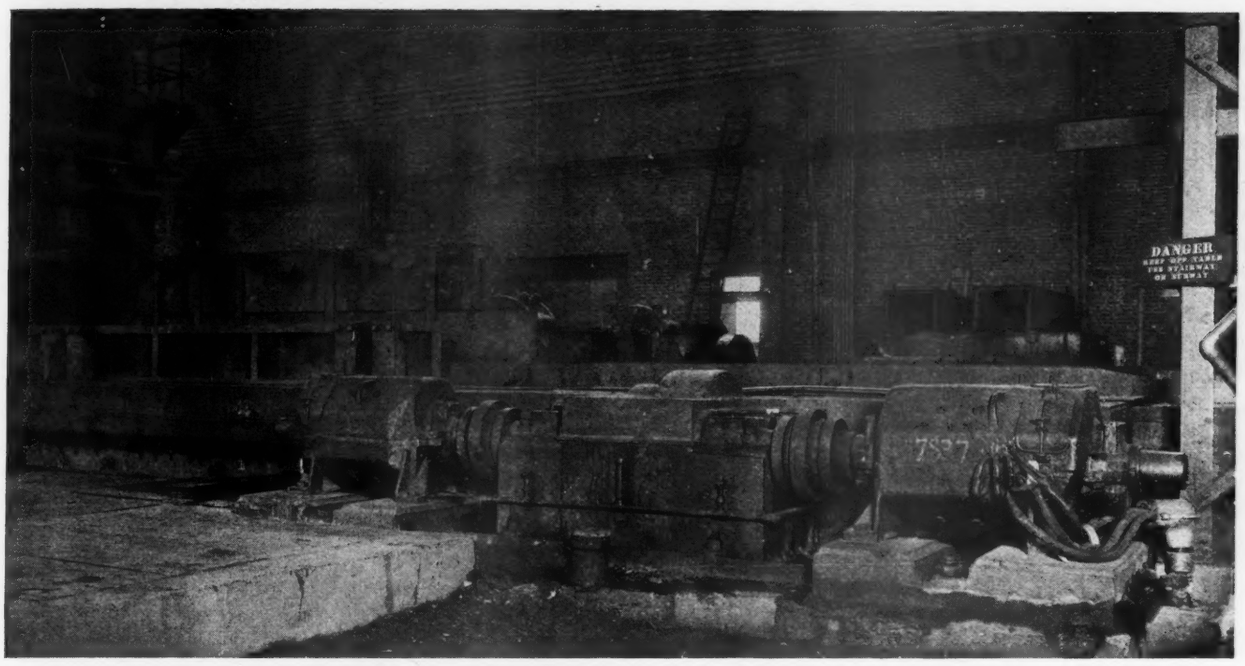


Fig. 1—Flexible couplings are widely used on steel mill auxiliary drives. Laminated disk couplings are used to connect the motors to the drive.

These two mill-type motors drive a geared line-shaft which in turn drives the individual rollers on the front table of a blooming mill.

Using Flexible Couplings on Motor Drives

By GORDON FOX
Electrical Engineer
Freyn Engineering Company,
Chicago, Ill.

AFTER having decided upon the type of motor and control for a given drive application, only half of the job has been performed. It is also necessary to select the mechanical element that will transfer rotary motion from the motor shaft to the driven machine. There are six common methods in general use for connecting the motor to the driven machine. These are: (1) By direct connection using solid or flexible couplings, or clutches. (2) By means of belts, ropes and accompanying pulleys and lineshafts, or short-coupled drives using modified belt or rope arrangements. (3) Through the use of roller, silent chain, or other forms of chains. (4) By means of gears or gear chains. (5) By the use of speed transformers or what are commonly known as speed reducers; and (6) by means of a special form of speed reducer known as the variable speed transmission.

These different mechanical elements will be discussed in a series of articles of which this is the first. This article will treat couplings and magnetic clutches, which are in reality a form of coupling.

Many motors are direct connected to the driven machine. Solid or rigid flange couplings would make an ideal connection were it not for the fact that they are too rigid and make no allowance for slight errors in misalignment or for the errors that come with wear of bearings, settling of frames or foundations, and other operating difficulties. With any misalignment and a rigidly connected shaft, experience shows that some of the troubles to be expected are: excessive shaft binding, loss of power through friction, excessive wear of bearings, difficulty of lubrication, and sometimes even broken shafts or couplings.

Perfect alignment, if it were possible to be attained and kept would be ideal. Builders of high-speed, direct-connected machinery such as turbines, line up shafts to within 0.003 or 0.004 in. On slower-speed machines, a greater allowance is usual and permissible. Hardly ever, however, on ordinary equipment does the misalignment exceed ☆ in. The result is that flexible couplings are required.

One of the most common complaints on flexible couplings arises from a mistaken belief that they will take care of any misalignment and do not need any attention after once being installed. In other words they are thought of as universal joints rather than flexible couplings. Flexible couplings do take care of a certain amount of misalignment, but operate much more satisfactorily both as to the coupling and as to the

machines, if maintained as nearly in perfect alignment as possible. It is not the function of a flexible coupling to compensate for careless or incompetent erection, nor for lack of reasonable maintenance attention.

One manufacturer of a very well known flexible coupling states, "We want to urge operators of direct-connected machinery that they line up their shafts initially just as carefully as they would do if they were attempting to use rigid couplings. This should be done whether or not the connected machines are received from the manufacturer and mounted upon a common bedplate, for bedplates will at times spring a sufficient amount to cause operating trouble. Therefore, the shafts

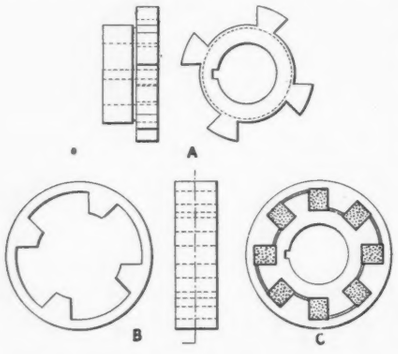


Fig. 2—This coupling uses standard hydraulic packing for the resilient material.

should be lined up after the bedplate is grouted into position. Also, the alignment of all direct connected machines should be checked at least once or twice a year. By checking the alignment it is not necessarily meant that the alignment will have to be corrected two or three times a year, but that in the case of many couplings where it is so easy to check the alignment by placing a steel straight edge across the wide flanges at the top, bottom, and sides, that the operator should spend a few minutes to do this rather than to run indefinitely and at some later date find that one bearing has worn to such an extent that the shafts are badly out of line. In such case he might have saved unnecessary wear in the coupling if he had checked the alignment at regular intervals, and corrected the alignment when he found the shafts were getting badly out of line."

Couplings of both solid and flexible types are in use for motor applications. Solid couplings may

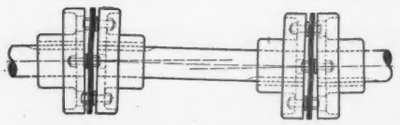


Fig. 3—This arrangement is used where a large amount of parallel misalignment must be compensated for.

Two, single type, flexible couplings are connected together by an extension shaft. The manufacturer of this coupling states that a maximum of 3/64 in. of parallel misalignment may be taken care of for each foot of extension shaft.

be used for motor-generator sets and for similiar applications where definite alignment of three or more bearings can be insured and where there is little likelihood of loss of alignment through bearing wear or movement of parts. Solid couplings are almost always of the safety flanged type.

Flexible couplings afford a considerable measure of protection to the motor. They should be used where accurate alignment cannot be definitely insured, where there is any possibility for relative movement between motor and driven machine, where hurried exchange of motors may be required, as in steel mill service, where there is some vibration or shock in the driven machine, or where an end thrust occurs which might be imposed upon the motor. Some types of flexible couplings may also be used for cushioning torque changes, as for reversing drives.

The flexible coupling is necessarily less simple than the solid flanged coupling. It is subjected to

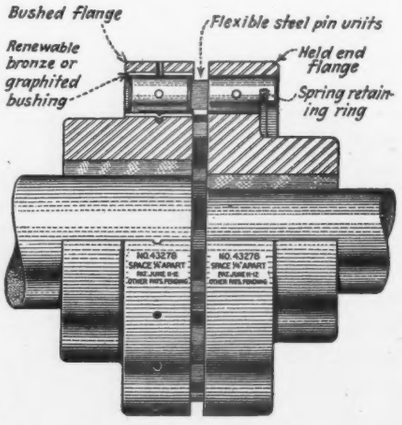


Fig. 4—Pin type of all metal flexible coupling.

Flexible steel pin units are held in bronze or graphite bushings placed in one of the flanges of the coupling as shown. The other end of the pin unit is held fast in the other flange. The steel pin units are free to slide ⅛ in. within the bushings.

and is expected to operate under faulty conditions. It is only recently that couplings have been developed that will withstand successfully the more severe applications. Although there are many designs of flexible couplings, they may be divided into two main classes, namely those that derive their flexibility through the use of a leather, rubber or fiber element and those that are made entirely of metal.

The leather link and leather laced belt coupling and the rubber buffer coupling are among the older types. The latter is still quite popular. Leather belt types are applicable where the torque is unidirectional. Rubber buffer couplings will not withstand serious misalign-

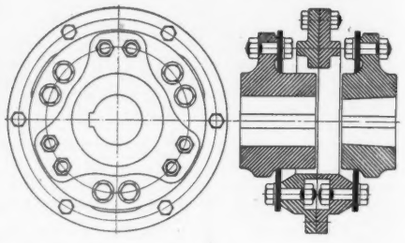


Fig. 5—This is the laminated disc, double-type coupling.

Laminated discs are fastened to each of the two coupling hubs and to a two-part central flange as shown at the left. This coupling can be quickly disconnected by removing the bolts holding the two halves of the central flange.

ment. Both leather and rubber are subject to deterioration and the rubber buffer type requires lubrication to minimize wear on the pins and bushings.

There has recently been introduced a coupling using standard hydraulic packing for the resilient material. This coupling consists of two duplicate flanges as shown at *A* in Fig. 2, one outer sleeve as shown at *B* and eight pieces of packing. The two flanges are keyed to separate shafts; the sleeve goes over the flanges and the packing is placed between the lugs on the flanges and sleeve respectively. The assembled coupling is shown at *C*. Steel springs and phosphor bronze retaining rings at each end of the outer sleeve hold the sleeve and packing in place. In this way the coupling is assembled without the use of any projecting bolts.

The construction of this coupling permits quick disconnection in order to change armatures on motor-driven applications. It is only necessary to remove the retaining

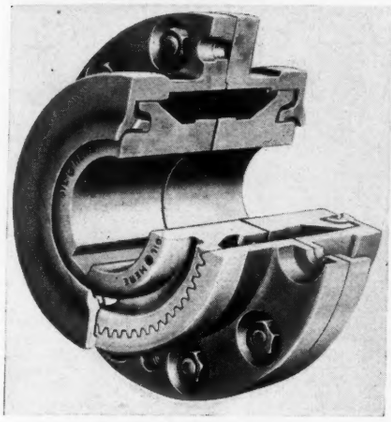


Fig. 6—A flexible coupling using a gear arrangement.

Each shaft hub has an external spur gear meshing with an internal gear on each half of the enclosing case. This then operates with a self-aligning action.

rings, slide back the sleeve and lift out the packing, whereupon the armature with its flange may be lifted out. This coupling compensates for both angular and parallel misalignment of shafts and permits end float. It is said to be adaptable to reversing as well as non-reversing drives.

All-metal couplings have features of desirability. They are particularly adapted for the more severe service applications finding extensive use, for instance, in the steel mill.

The all-metal couplings may be classified into those types (1) that use pins, (2) those that use laminated discs, (3) those that use springs, and (4) those that use an arrangement of internal and external spur gears.

The pin type of all-metal coupling uses pins that project from each of two flanges into holes in a central disc composed of fiber or leather. The holes in the central disc are slightly larger than the pins which permits the coupling to automatically adjust itself for misalignment.

Another form of pin type coupling uses horizontal laminated steel pins projecting into a central disc made of steel, while a third form uses radial laminated pins which project into slots in a central sleeve placed over them. These types of couplings have been extensively used and are popular. The pin laminations may break after a long period of service, but they do not fail all at once, giving warning if occasionally inspected. Theoretically this type of coupling should relieve end thrust. Practically it is not very effective in this respect as the pins are subjected to stress and they do not readily permit endwise movement unless well lubricated. It is difficult to renew pins in this coupling as they become distorted and take a permanent set so that the pin sockets are out of line. For like reasons, single couplings of this type in which the pins must be removed in separating the coupling, are not adapted to quick changes of motors. Double couplings of this type can be separated without removing the pins. This coupling affords a slight degree of torque cushioning on reversing drives.

A coupling in which the objections mentioned in the foregoing have been removed is shown in Fig. 4. Graphite bushings are used in this coupling so that the coupling is self lubricated. The steel pin units are

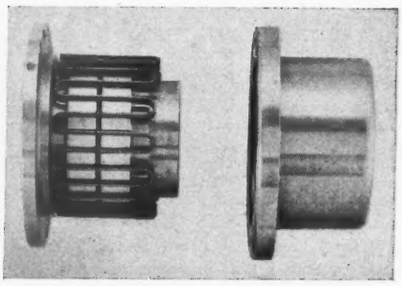


Fig. 7—Well known form of spring type coupling.

The two hubs have tapered slots into which fit tempered steel springs. The slots in the hubs widen inward towards each other so that the spring fits closely in them only at the outer ends and so permits flexibility.

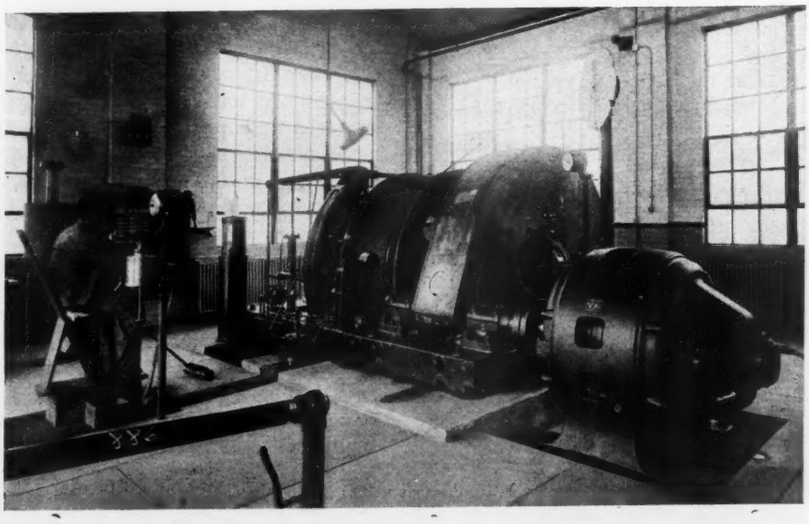
free to slide ½ in. within the bushings thereby relieving end thrust on the coupling. Flexibility is obtained by means of the flexible steel pin units shown in the illustration. The coupling is quickly disconnected for changing motors by removing the spring retaining ring indicated in Fig. 4.

An all metal coupling using laminated discs for the flexible element is shown in Fig. 5. Both single and double couplings of this type absorb end movement excellently. This type of coupling requires no lubrication. It affords little if any torque cushioning effect.

Flexible pin and laminated disc type couplings may be either single or double. The single coupling provides but one flexible element. The double coupling provides two flexible elements and a central floating member. Fig. 5 is a section of a double coupling of the laminated disc type. The single coupling will withstand a little misalignment, perhaps, but very little offset of shafts. The double coupling will operate successfully with greater misalignment and with a slight offset of shafts. Where considerable offset or play in one shaft exists, the condition can be met by separating the two single flexible members and extending the floating member by a spindle, as shown in Fig. 3. The double coupling permits quick exchange of motors or armatures as the floating member is split.

In some types of all-metal flexible couplings, coil springs are used to join the flanges either in compression or in tension between interlocking arms of the two flange members. Such a flexible coupling is shown in Fig. 10. This one as well as the couplings shown in Figs. 7 and 9 are well suited for cushioning torque

Fig. 8.—The motor driving this mine hoist is connected to the reduction gear by means of a flexible coupling.



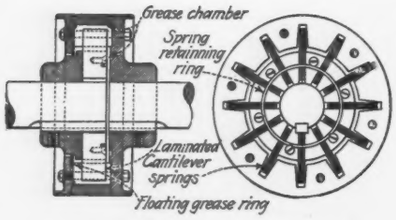


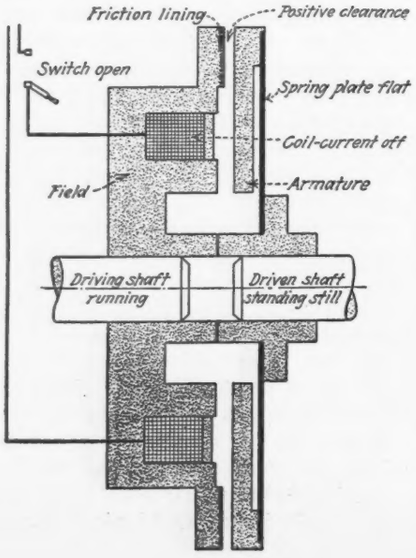
Fig. 9—Spring-type flexible coupling in which the springs form the teeth of a spur gear which meshes with an internal gear.

shocks and absorbing the back lash in a reversing drive.

The coupling shown in Fig. 7 comprises essentially two hub members keyed to the shafts, each hub having external teeth somewhat resembling a spur gear. Hairpin spring segments are interleaved in the slots between the gear teeth. These slots are wider at their adjacent ends than at their outer ends. When the load is light the spring segments contact with the outer ends of the teeth and the torque is transmitted through the spring members acting as beams. As the load increases, the spring members deflect and contact is made nearer the adjacent ends of the teeth. Under heavy loads the springs are fully deflected and the central part of the springs transmits all the torque, being subjected to almost pure shear. The deflection of the springs above mentioned requires some relative movement of one hub with respect to the other. The back lash thus introduced affords a cushioning effect as it is gradually absorbed in the springs without impact. This type of coupling permits end movement and some misalignment. It requires lubrication, being grease packed.

The fourth type of all metal coupling is that using an arrangement of gears. In Fig. 6 is shown a double-type coupling of this character that is meeting with favor. The hubs keyed to the shafts carry external spur gears. A floating sleeve, carrying internal spur gears at each end, surrounds the two hubs. The gear teeth of the sleeve permanently engage the gear teeth of the hubs. The sleeve has lateral and angular play. To correct for misalignment a sliding action takes place between the external and internal gear teeth. Lubrication is necessary for this coupling. Oil is used and is thrown to the interior circumference of the sleeve and into the gear teeth by centrifugal force. The floating member is split as in a flanged coupling. This type of coupling provides no cushioning of torque. It will withstand moderate misalignment and offset of shafts and absorbs end movement.

Closely allied to the coupling as a means of connecting the motor to its drive is the clutch. The clutch is similar to a coupling so arranged that the halves can be quickly disconnected thereby permitting part of the drive to run while the rest does not. This form of connection is particularly advantageous when the motor will not readily start the load,



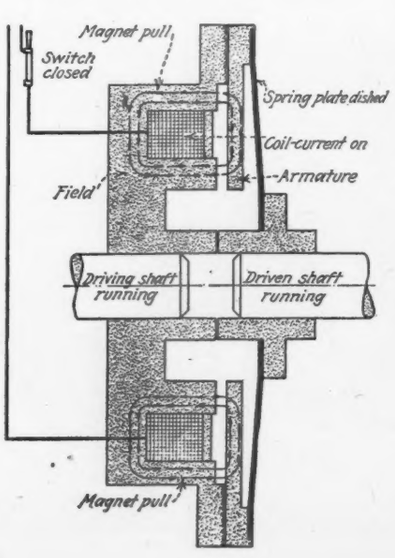


Fig. 10—The magnetic clutch is often used to connect the motor directly to the driven machine.

The drawing at the left shows the position of the clutch parts when disengaged. In the drawing at the right, current has been applied to the magnet winding thereby attracting the armature or flange connected to the driven shaft so that the friction plates are in contact. In this way it picks up the load gradually, as it requires a short time for the magnets to become completely energized.

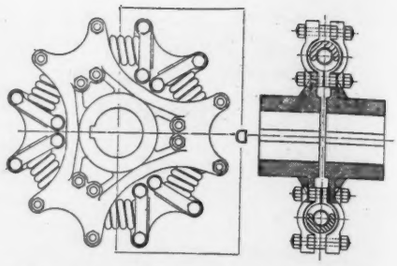


Fig. 11—Another type of spring coupling.

Coil springs under compression supply the desired resiliency and flexibility.

but will start it provided the motor can first be brought up to speed before being connected to the load.

There are many forms of clutches and cut-off couplings, but for the purpose of this article we may think of them as falling into two classes, those employing mechanical methods of engagement and those in which the friction surfaces are magnetically operated. The first class has found wide application on lineshafts, countershafts, and also on the individual driven machine. The magnetic clutch, on the other hand, has found particular favor, when used in direct connection with the motor. For this reason this discussion will be confined to the magnetic clutch.

The magnetic clutch is primarily a means for readily connecting and disconnecting a motor from the driven machine, either while at rest or when in motion. The general construction of this unit is shown in Fig. 10. It consists essentially of a field or driving member and the armature or driven member. The armature is carried on a spring steel plate. This plate holds the friction faces normally out of engagement. When current passes through the winding of the field member, the armature is attracted to it, causing the friction surfaces to be engaged. The turning power of the clutch is transmitted entirely by the friction surfaces under pressure due to magnetic attraction. In accelerating a load there is some slippage between these surfaces. In some cases the clutch may be gradually applied by inserting a rheostat in the field winding circuit and gradually increasing the excitation. This permits a very smooth acceleration.

Magnetic clutches are particularly suited where frequent starting and stopping is desired and may be used in lieu of starting and stopping the motor. They permit of remote con-

(*Please turn to page 569*)

Delta-delta connected outdoor installation of transformers used for industrial purposes. The bank at the left has a bus for completing the low-tension connection while the high-tension connections are made through lead sheath cable connecting to buses within the building.

Connecting Transformers To Three-Phase Circuits

By L. F. GOSS
Chief Engineer, Kuhlman Electric Co., Bay City, Mich.

A discussion of the factors affecting the operation of transformers in parallel and the selection of transformers for industrial service

IN THE FIRST part of this article, which was published in the November issue, it was pointed out that to the man buying or operating industrial transformers, ever present problems are: What manner of transformer connection will best fit the requirements? How may transformers be operated in parallel? Factors that should be considered in the purchase of a transformer. Considerations affecting transformer efficiency, regulation, and power factor. In the first section of this series of two articles the question, "What manner of transformer connection will best fit the requirements?" was answered. This article will treat the remaining factors that have just been enumerated. We will first consider the operation of transformers in parallel.

The satisfactory parallel operation of transformers is definitely dependent upon five principal characteristics; that is, any two or more transformers which it is desired to operate in parallel should possess: (1) The same inherent phase angle difference between primary and secondary terminals; (2) the same voltage ratio; (3) the same percentage impedance; (4) the same polarity; and (5) the same phase rotation.

To a much smaller extent, parallel operation is affected by the relative outputs of the transformers, but actually this aspect is reflected in the third characteristic, for if the disparity in outputs of any two transformers exceeds a certain figure, it is extremely difficult to incorporate sufficient impedance (without resorting to the use of magnetic shunts) in the smaller transformer to produce the correct loading conditions for each individual unit.

Characteristics (1) and (5) given in the foregoing apply only to polyphase transformers. A very small degree of latitude may be allowed with regard to the second characteristic mentioned, while a somewhat greater tolerance may be allowed with the third, but the polarity and phase rotation where applicable, of all transformers operating in parallel, must be the same.

The theory of the parallel operation of single-phase transformers is essentially the same as for three-phase, but the actual practice for obtaining suitable connections between any two single-phase transformers is considerably simpler than the determination of the correct connections for any two three-phase transformers.

(1) *Phase angle difference between primary and secondary terminals.* In single-phase transformers this point does not arise, as by the proper selection of external leads any two single-phase transformers can be connected so that the phase angle difference between primary and secondary terminals is the same for each. Consequently the question really becomes one of polarity.

(2) *Voltage ratio.* It is very desirable that the voltage ratios of any two or more transformers operating in parallel should be the same, for if there is any difference whatever, a circulating current will flow in the secondary windings of the transformers which are connected in parallel, but before they are connected to any external load. Such a circulating current may or may not be permissible according, first, to its actual magnitude, and second, as to whether the load to be supplied is less than or equal to the sum of the rated outputs of the transformers operating in parallel. As a rule, however, every effort should be made to obtain identical ratios, and particular attention should be given to obtaining these at all ratios when transformers are fitted with adjusting taps. In passing, it may be well to point out that when a manufacturer is asked to design a transformer to operate in parallel with existing transformers, the actual ratio of primary and secondary turns should be given, as this ratio can easily be obtained exactly. Such figures would, of course, be obtained from the original manufacturer of the existing transformers.

(3) *Percentage impedance voltage.* The percentage impedance voltage, which is a factor inherent in the design of any transformer, is a characteristic to which particular attention must be paid when considering parallel operation. The percentage impedance voltage is determined by the formula.

$$IZ = \sqrt{(IR)^2 + (IX)^2}$$

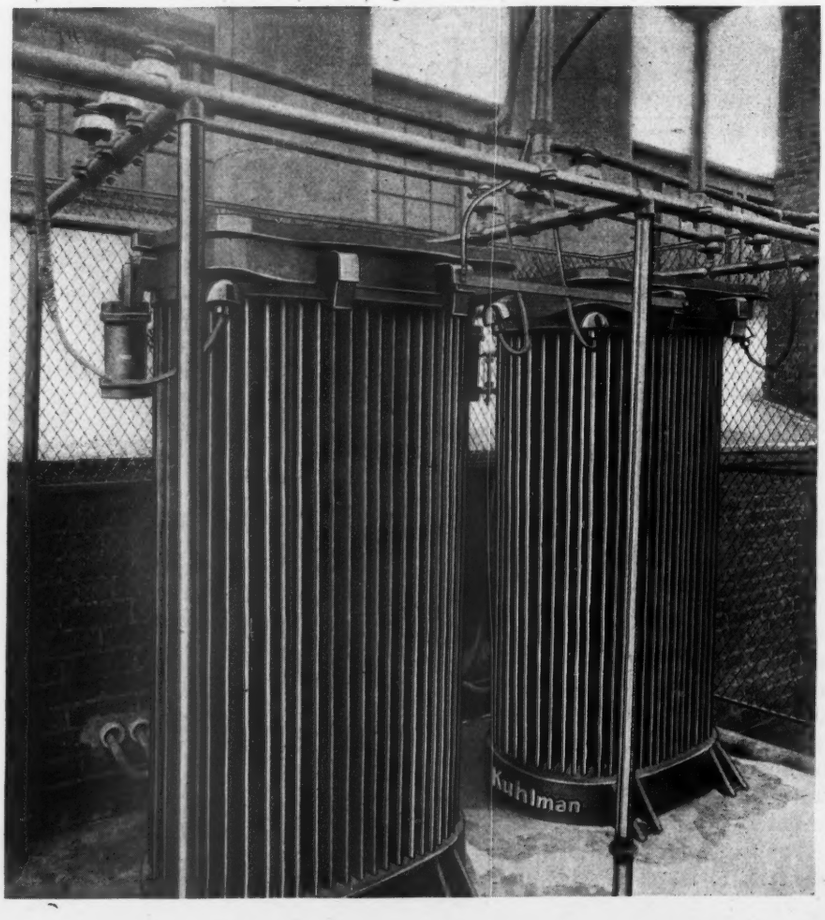
where IZ is the percentage impedance drop, IR the percentage resistance drop and IX the percentage reactance drop. The value of I is, of course, inserted to correspond with the normal full-load current of the transformer. Assuming that all other characteristics are the same, the percentage impedance voltage determines the load carried by each transformer, and in the simplest case, viz., of two transformers of the same output operating in parallel, the percentage impedances must also be identical if the transformers are to share the total load equally. If, for instance, of two transformers connected in parallel having the same output, voltage ratio, and the like, one has an impedance of 4 per cent and the other an impedance of 2 per cent, the transformer having the larger impedance will supply a third of the total bank output, and the other transformer will supply two-thirds, so that the transformer having the higher impedance will only be carrying 66 per cent of its normal load, while the other transformer will be carrying a 33 per cent overload.

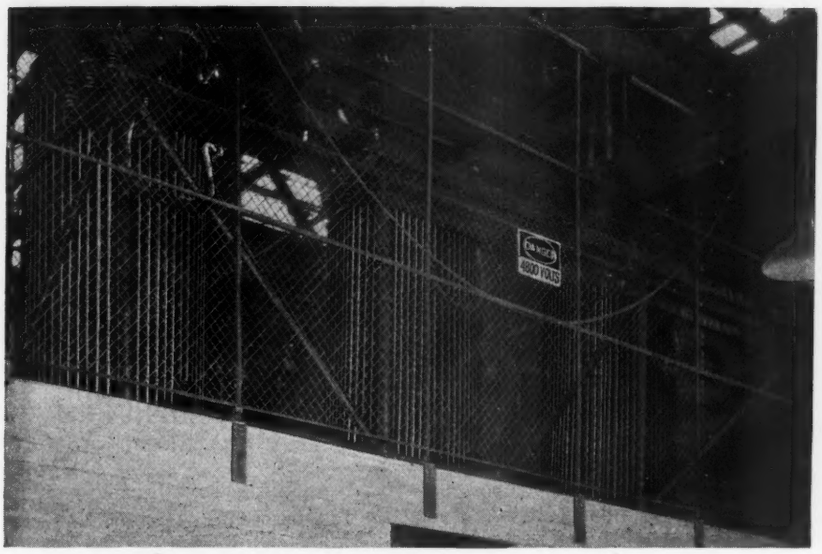
When operating transformers in parallel, the smallest transformer should not be less than one-fifth of the output of the largest, as otherwise it is extremely difficult, as mentioned above, to incorporate the necessary impedance in the smaller transformer.

(4) *Polarity.* The term polarity when used with reference to the parallel operation of electrical machinery is understood to refer to a certain relationship existing between two or more units, and it is not applied to any single unit considered alone. Any two single-phase transformers have the same polarity when their instantaneous terminal voltages are in phase. With this condition, a voltmeter connected across similar terminals will indicate zero.

Single-phase transformers are essentially simple to phase in, as for any given pair of transformers there are only two possible sets of external connections, one of which must be correct. If two single phase transformers, say X and Y, have to be phased-in for parallel operation, the first procedure is to connect both primary and secondary terminals of say, transformer X, to their corresponding busbars, and then to connect the primary terminals of trans-

Open-delta connected indoor installation of transformers at plant of Standard Brass Manufacturing Co., Detroit, Mich.





This installation transforms the power for the Detroit Copper & Brass Rolling Mills, Detroit, Mich.
It is located on a balcony in one of the mills and is screened off for protection to workmen.

former *Y* to their busbars. If the two transformers have the same polarity, corresponding secondary terminals will be at the same potential, but in order to ascertain if this is so, it is necessary to connect one secondary terminal of transformer *Y* to what is thought to be its corresponding busbar. It is necessary to make the connection from one secondary terminal of transformer *Y* so that when taking voltage readings there is a return path for the current that is flowing through the voltmeter.

Voltage across the disconnected secondary terminal of transformer *Y* and the other busbar is then measured, and if a zero reading is obtained, the transformers have the same polarity, and permanent connections can accordingly be made. If, however, the voltage measured is twice the normal secondary voltage, then the two transformers have opposite polarity. To rectify this, it is only necessary to cross connect the secondary terminals of transformer *Y* to the busbars. If, however, it is more convenient to cross-connect the primary terminals, such a procedure will give exactly the same results.

(5) *Phase rotation.* In single-phase transformers, this point does not arise, as phase rotation is a characteristic of polyphase transformers.

In the case of polyphase transformers special attention must be given to characteristics (1) and (5). However, let us consider all characteristics in order.

(1) *Phase angle difference between primary and secondary terminals.* The choice of suitable external connections which will enable two or more polyphase transformers to operate satisfactorily in parallel is much more complicated than is a similar choice for single-phase transformers, largely on account of the phase angle difference between primary and secondary terminals of the various connections. It becomes necessary, therefore, to study carefully the terminal connections of polyphase transformers which are to be operated in parallel before attempting to phase them in.

It should be noted that the question of phase displacement is one of displacement between the line terminals, and not necessarily of any internal displacement which may occur between the vectors representing the voltages across the individual phase windings.

(2) *Voltage ratio.* (3) *Percentage impedance voltage.* (4) *Polarity.* With polyphase transformers exactly the same remarks apply to these three items as was outlined for single-phase transformers.

(5) *Phase rotation.* When phasing in any two or more transformers, it is essential that both their polarity and phase rotation should be the same. The phase rotation may be clockwise or counter-clockwise, but so long as it is the same with both transformers, the direction is immaterial. It is generally advisable when installing two or more transformers for parallel operation, to actually make a test for the purpose of definitely ascertaining that corresponding secondary terminals have the same instantaneous voltage magnitude and phase.

Considerations Affecting the Selection of Transformers

The outstanding features of a transformer, which should receive careful consideration by the prospective purchaser are, reliability, iron loss, copper loss, and impedance.

(1) *Reliability.* In both design and manufacture, the reliability of a transformer should be given first consideration. The principal factors bearing on reliability are: sound mechanical construction; liberal oil ducts and electrical clearances; current and induction densities sufficiently low to avoid excessive local heating; liberal radiating surfaces; and good oil, preferably of the non-sludging grade.

All these factors tend to increase the first cost of a transformer, and the first three tend to reduce the efficiency, but these disadvantages are outweighed by the saving in cost of repairs and the advantage of insuring continuity of service.

(2) *Iron loss.* The iron loss of a transformer should be reduced to a minimum since this loss is constant and continuous during the whole of the time the transformer is connected to the mains. While, however, a low iron loss is undoubtedly a great advantage, it should not be obtained at the expense of a very high copper loss, and thereby the probable sacrifice of reliability.

(3) *Copper loss.* It should be remembered that the operation of a commercial transformer of given proportions and for a given output entails the loss of a certain and fairly constant total amount of power, consisting generally of iron and copper losses. Acceptance of this statement implies, therefore, that if the iron loss of a commercial transformer is very low, the copper loss will be correspondingly high and vice versa. A high copper loss may represent a distinct menace to the coil insulation on account of the possibility of excessive undetermined local heating occurring in the interior of the coils, and therefore it is far sounder practice to design for a closer agreement between copper and iron losses than to aim for a very low iron loss at the expense of the copper loss or of the electrical or thermal design of the transformer.

(4) *Impedance.* The effect of impedance upon regulation is important

as a high impedance entails a high regulation at the lower power factors. High regulation as such is certainly an undesirable feature, but it must not be overlooked that a reasonably high impedance is the best protection against the damage a transformer is liable to sustain due to external short circuits. In deciding, therefore, what impedance a transformer should have, reliability and safety should be given preference. In this connection, the question of parallel operation is of importance, since the impedance of a transformer which has to operate in parellel with an existing transformer should be equal to the impedance of the latter. When, however, such an impedance is too low for satisfactory service under modern conditions, it is better to insert separate impedance coils in series with the existing transformer, than to perpetuate a design which is no longer in accordance with sound modern practice.

Determining Regulation of Transformers

Efficiency—The losses in a transformer comprise the iron and the copper losses and sufficient power is consumed at the primary terminals of the transformer to supply both the load and losses. The relation between the load W plus the losses w to the load W is the efficiency.

$$\text{Per cent efficiency} = [W \div (W + w)] \times 100$$

Given a 200-kva. transformer with a core loss of 744 watts and a copper loss of 2,350 watts, the full-load efficiency will be

$$[200{,}000 \div (200{,}000 + 744 + 2{,}350)] \times 100 = 98.6 \text{ per cent}$$

The core loss remains constant irrespective of the load, but the copper loss varies as the square of the load.

The copper loss in the above example at three-quarter load will be:

$$(0.75)^2 \times 2{,}350 = 1{,}332 \text{ watts.}$$

The efficiency at this load will then be:

$$(0.75 \times 200{,}000) \div [(0.75 \times 200{,}000) + 1{,}332 + 744] \times 100 = 98.7 \text{ per cent.}$$

The core loss is not affected by temperature, but the copper loss increases as the temperature increases, and all guarantees are made on the basis of 75 deg. C.

Regulation—The regulation of a transformer is affected by both impedance watts, or copper loss and by reactance. In any transformer some of the lines of force, instead of going through the iron, leak through the coils. This leakage flux generates an opposing voltage called reactance volts in the coils which reduces the delivered volts under load, and this is especially noticeable in loads of low power factor.

The delivered volts on a non-inductive load, that is a load consisting of resistance only, will be reduced by the following amount from what would be expected from the turns ratio alone.

$$\text{Per cent regulation} = qr + [(qx)^2 \div 200]$$

where qr = per cent impedance watts, also called IR drop

and qx = per cent reactance volts.

As an example let us calculate the delivered volts under full load for a 200-kva., 2,300/230-volt transformer having 2,350 watts copper loss and 3 per cent reactance volts.

The impedance watts qr will be equal to the copper loss divided by the full-load rating of the transformer, or $qr = (2{,}350 \div 200{,}000) \times 100 = 1.175$ per cent.

$$\text{Per cent regulation} = 1.175 + (3^2 \div 200) = 1.22 \text{ per cent.}$$

The actual delivered volts from the above transformer with a non-inductive load will be:

$$(100 \text{ per cent} - 1.22 \text{ per cent}) \times 230 = 227.2 \text{ volts.}$$

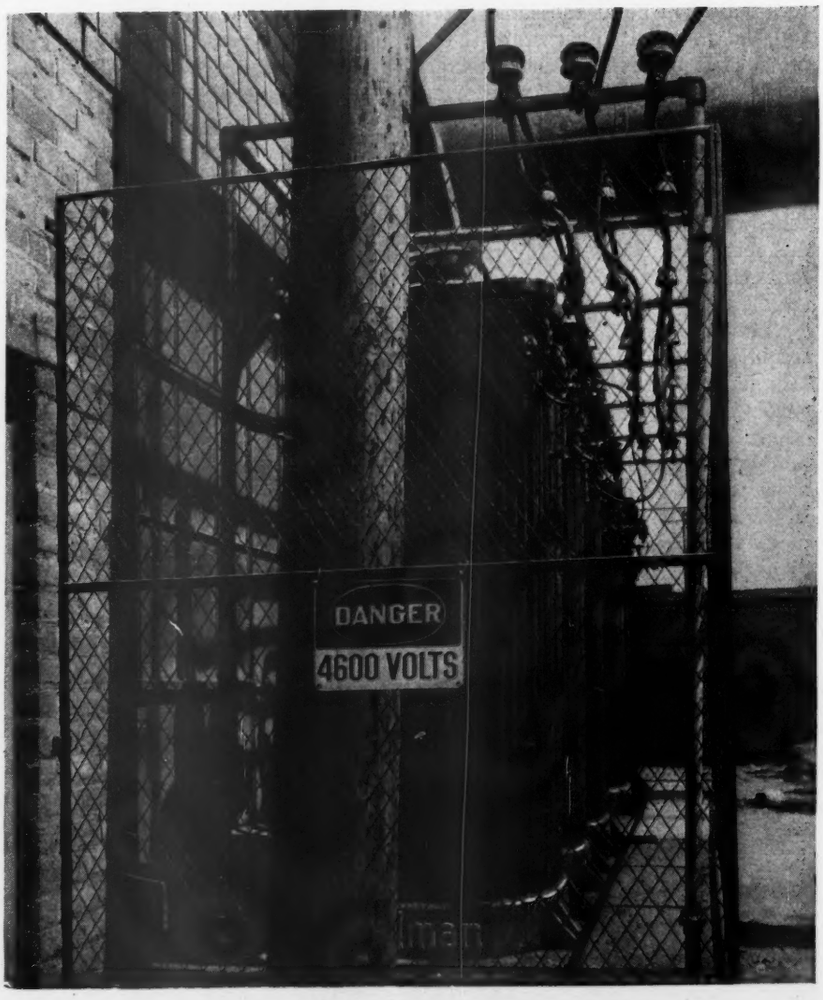
All standard regulation guarantees are based on a load at 80 per cent power factor and the formula for regulation at power factor m and reactive factor n, is:

$$\text{Per cent regulation} = m \times qr + n \times qx + [(m \times qx - n \times qr)^2 \div 200]$$

Assume the same transformer as in the preceding example operating with a load at 80 per cent power factor and the corresponding 60 per cent reactive factor. In this case the per cent regulation at full load will be:

$$\text{Per cent regulation} = 0.8 \times 1.175 + 0.6 \times 3 + [(0.8 \times 3 - 0.6 \times 1.175)^2 \div 200] = 2.75 \text{ per cent.}$$

The actual delivered volts under this load will be:



This outdoor installation transforms power received at a 4,600-volt potential for the Detroit plant of the Federal Bearing & Bushing Co.

(100 per cent — 2.75 per cent) × 230 = 223.6 volts

Power Factor—In a direct-current circuit the volts × the amperes = watts, but in an alternating current circuit that has any inductance, such as motors, the volts × amperes will not equal the watts as indicated on a wattmeter, but will give a result that is greater than the actual watts. The relation between these two is the power factor of the circuit, and is expressed by the following equation:

[watts ÷ (volts × amp.)] × 100 = per cent power factor.

If the watts equaled the volt-amperes, the power factor would be 100 per cent and the circuit would be non-inductive.

Assume a load of 150 kw. having a power factor of 80 per cent. The transformer capacity required to carry this load will be:

150 ÷ 0.8 = 187.5 kva.

The nearest standard size is 200 kva. and this size should be used.

Exciting Current—The item of exciting current is considered of importance by some especially where there are a large number of distribution transformers on the system under a part time load. This is the current that flows in the primary when there is no load on the secondary and has a very poor power factor. The volt-amperes of exciting current or apparent watts consists of the core loss and a little copper loss due to the exciting current, both of which are power components, and the magnetizing current, which is out of phase.

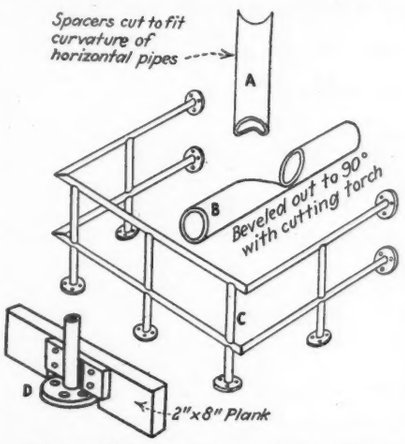
The exciting current is principally objectionable as it causes line loss and requires some generator capacity to supply. While it is impossible to eliminate it entirely, modern transformer design tends to reduce it.

Method of Fabricating All-Welded Pipe Railings

A LARGE Eastern shop desired to have a 2-in. pipe railing built on very short notice. It was found that there were no railing fittings of the desired size available; so their welding department was asked to do the job. The result was most pleasing to the officials of the plant, and the method of construction, as stated in the *Welding Engineer*, is one that can be used wherever welding is available.

As shown at *C* in the accompanying diagrams, all of the pipe used was of short length. No patterns of any kind were necessary, and the only tools that were used besides the torches were a square, a hammer, a centerpunch, a pair of dividers, and a vise.

In making up a railing the corners of the railing are formed by cutting a large V at the desired point, as shown at *B* in the diagram, care being taken not to cut all the way through the pipe. The pipe is then bent at right angles, the joint very carefully squared and lined up, after which it is tack-welded.



These diagrams show the principal steps involved in building a welded pipe railing.

The spacers, shown at *A* in the diagram, are all cut off in the pipe cutting machine or with the torch, a great deal of care being taken to see that they are all of the same length, and the ends are all notched out to fit the curvature of the horizontal railings. To assemble the railing, lay the top horizontal rail, that has already been bent and tack-welded, on the floor, and measure off and mark where the spacers are to go. After squaring up the spacers, in all directions, with the top horizontal rail, tack-weld the spacers into a vertical position, tacking securely enough so that the pipe will stand considerable handling. Lay the bottom horizontal railing on the floor, turn over the top rail that has the spacers welded to it, so that the spacers point downward, and place the lower end of the spacers on top of the railing that is on the floor. Line up this railing with the spacers and, after checking with the square, tack-weld the spacers to the rail.

The floor flanges are made of ¼-in. boiler plate and are cut to a 5-in. diameter. The bolt holes are four in number and are ½ in. in diameter. The flanges are cut with the cutting torch. The holes are drilled and the edges of the plates are cleaned before the legs of the railing are welded to them. The legs are made in the same way as the spacers, except that one end of the legs is left square. The square end of the leg is tack-welded to the floor plate and the leg in turn is tack-welded to the railing, after the railing has been turned upside down. After all tacking is done, the railing is turned right side up and a neat welding job is done on all joints, care being taken to see that all joints are square and in line with other parts. The wall flanges can be welded last.

Sketch *D* in the diagram shows a method of attaching a kick board to a railing. These kick boards are required by a good many safety engineers and are used at the bottom of a railing which is around an overhead platform or a pit. These boards prevent tools and other objects from being kicked onto workers below.

The plant mentioned above has built both kinds of railings, the threaded fitting railing and the all-welded railing. In both cases the pipe used was old and useless for any other purpose. Cost figures showed, however, that the welded railing could be built at about half the cost of a similar railing of the same length in which tees, crosses and elbows were used.

Flexible Couplings for Motor Drives

(Continued from page 564)

trol and easy application. They provide a ready and quick means of mechanical disconnection and are therefore frequently applied as a safety feature. They are frequently used to permit starting a motor without load, the clutch being energized after the motor has attained normal speed. This practice applies particularly to synchronous motors. They are mechanically simple, normally balanced and may be used for higher speeds and heavier duty than other types of clutches. They do not require lubrication.

Where magnetic clutches are installed as a safety provision, a magnetic brake is generally provided in conjunction, to stop the machinery after the motor is disconnected.

Practical pointers on

Mush or Hit-and-Miss Armature Coils

with details of the procedure employed in obtaining the data needed in making up these coils in the different types used in motor windings

THIS is the first of a series of articles that will deal with the types of coils that the average repair shop will use in the repairing and rewinding of motors and generators. The subject will be treated in such a manner as to enable the average repair shop to make up the simple and inexpensive tools required to make coils for a single job, along with hints and ways to increase production on coils made in large quantities. Practical details will be given for each type of coil now commonly used and the ways they can be employed in different types of a.c. and d.c. windings.

By A. C. ROE
and
D. H. BRAYMER
Consulting Editor, Industrial Engineer

IT IS a recognized fact that well-shaped coils and good insulation properly applied are the foundation of any electrical winding used in the stator or rotor of a rotating machine. Therefore, it is obvious that the useful life of the repaired machine depends upon the skill and knowledge of the coil maker. The broader this man's experience and knowledge of windings as applied to a.c. and d.c. machines, and also of wire and insulation, the better will he be able to develop a coil and insulate it for any type of machine brought in for repairs.

By a knowledge of windings is meant the winding rules, types and connections of electrical windings, such as lap and wave, for a.c. and d.c. machines. Actual experience in repair work will in many cases enable a winder to simplify a difficult job by changing the type of winding.

The making of coils from a repair shop standpoint is considerably different from the manufacturer's viewpoint. The motor manufacturer develops special tools and trains a certain group of employees to make one type of coil in large quantities. In some cases the routine handling of coils through the various manufacturing steps may require one or more operations that would be unnecessary in the average repair shop. The repair shop, on the other hand, has to make a number of different types of coils every day with the tools on hand and a small force of workers. In every case, therefore, the cost and number of special tools for any one set of coils must be kept to a minimum. This forces the average repair shop to train a small force to be all-around coil men who can wind, pull, tape and perform all of the details of coil making.

Here is where the repair shop is fortunate, for young men or boys taking courses in night schools can be trained to make coils and thereby get training that later will enable them to wind small motors or medium-sized a.c. stators or d.c. armatures. A repair shop is a fine school for any man or youth who desires to go into any branch of electrical work. Electrical apparatus of all kinds is brought into the average repair shop, from the coffee percolator to large rotary converters, while transformers and other equipment that is too large to be taken to the shop, is repaired in the field where service conditions can be observed and studied at first hand.

The average young man, after spending 12 or 18 months in making coils, has a practical respect for coils and insulation in general and knows what skinned spots on wire and chafed insulation on a coil mean. With such knowledge he is in a far better position to judge where extra insulation is required and when and where to use special care in the winding and handling of complete machines.

The repairing of electrical apparatus can be divided into two distinct and separate parts, as follows: (1) The repair shop that caters to the plants in the surrounding district and repairs electrical machines of all makes and types. (2) The repair shop located in an industrial manufacturing plant whose one and only function is to repair the motors and other electrical equipment for this one plant only.

In many instances both these repair shops have an advantage over the electrical manufacturer. The manufacturer must develop a standard range of motors for 110, 220, 440, and 550 volts and in some cases, as with induction motors, the windings are designed so that the motors can be carried in stock rated at 220 volts, and reconnected for 110- or 440-volt operation, or other schemes may be used to reduce stock and tools and provide straight-line production.

When a motor or other piece of apparatus has been purchased for a definite purpose and its voltage is fixed, this works out to the repair shop's advantage in some cases and is the basis for the statement already made that the coil man should know something about the construction of a.c. and d.c. motors and generators. The following cases will illustrate this point. Assume that a 220-volt induction motor is up for repairs and the stator is to be rewound. After checking the coils used we find it requires 54 turns of one No. 15 d.c.c. wire and 72 mush coils. The coil man on checking the winding data finds that the motor was connected two-parallel star for 220 volts. He then advises the shop foreman to change the connection to series-star for 220 volts, as he will wind the

coils with 27 turns of two No. 15 d.c.c. wires in hand. This will save 27 turns on each coil, reduce the labor, and provide a satisfactory winding.

Or again, the coil may be one that is wound with a small size of wire with the wires arranged in layers and the coil well shaped. It may have 20 turns of one No. 18 d.c.c., four wide by five deep for a voltage of 110 d.c. Here the coil man sees a chance to change to a flat, mush type of coil using No. 18 single-cotton and enamel-covered wire.

A good coil man checks each job from the coil back to the complete machine for opportunities to save time and improve the winding. For instance, a check on a d.c. machine revealed that the brush-holders could be shifted 45 mechanical degrees. This helped to eliminate a mean bottom lead connecting job and also stopped the brushes from sticking in the bottom brush-holder box.

Ribbon wire can be used to replace three or more round wires in parallel, and numerous other combinations can be made to save time on a rewinding job when it is properly studied and handled.

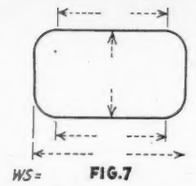
The industrial plant that does its own rewinding can save in this department by standardizing on one or a small number of different makes, types and standard ratings of motors. This will reduce spare parts to a minimum and the repair shop can handle its coil and rewinding work to better advantage, as a slight change might make one coil suitable for a number of other motors, thus calling for a large quantity of one kind of coil.

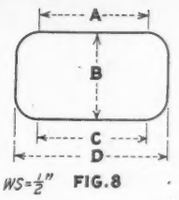
Mush Coils—By the term "mush" is meant coils not wound in layers and sometimes called "hit-and-miss" coils. The wires are allowed to pile up by winding slowly back and forth across the wire space or winding room on the mold. When winding mush or hit-and-miss coils, care should be taken not to allow the wire to make a sudden cross from one side of the mold to the other.

The mush coil is frequently used in both a.c. and d.c. machines and its use is increasing. With improvements in insulation and types of wires, the use of mush coils will be further increased and, therefore, this coil is worthy of considerable study.

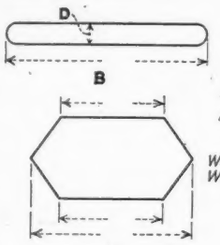
In order to avoid repetition of information already presented, readers are referred to the information on coils that has appeared in the following issues of INDUSTRIAL ENGINEER: (1) Diagrams for Coil Winders, by A. C. Roe, page 283, June, 1922, issue. (2) Shop Practice and Details of Coil Making Methods, by A. C. Roe, July, 1922, issue. (3) Methods for Laying Out Coils for D.C. Armatures and A.C. Stators, by A. C. Roe, page 159, April, 1922. These articles give considerable coil data and details of card records and how to lay out coils.

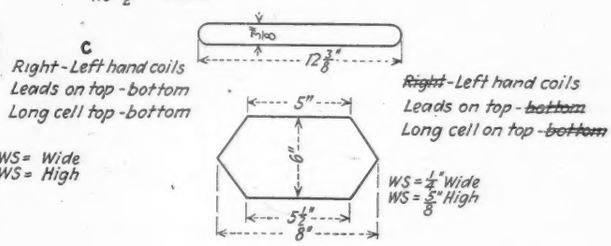
The keeping of coil records is one of the important items in repair work and the system used must be flexible and simple. The coil data should be tied in with an order number and the name of the customer, in commercial shops, and with the motor type and serial number in industrial plant repair shops.





COIL NO.	A	B	C	D	NO. OF COILS
1					
2					
3					
4					
5					
6					



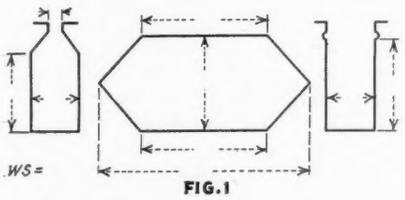


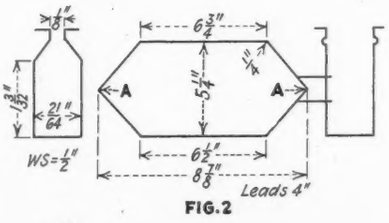
Figs. 7 to 10—Diagrams that can be used for recording dimensions and lead positions for mush coils of the concentric-chain type used in single-phase motors.

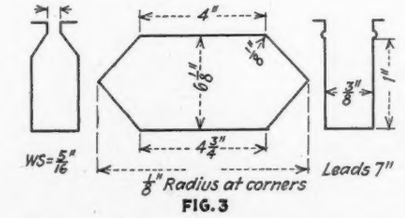
Fig. 7 shows a skeleton diagram providing spaces for dimensions. Fig. 8 shows this diagram for use with a table in cases where a number of different sizes of coils are used. Fig. 9 illustrates the diagram that can be used for mush pulled coils providing dimensions for the winding loop and notations for the type of coil. Fig. 10 shows Fig. 9 filled in for a left-hand rotor coil with the leads on top, the long cell on top, and the leads brought out on the end of each cell in the winding slot.

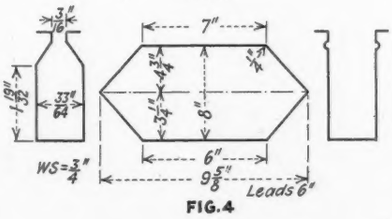
Figs. 1 to 6—Diagrams that can be used for recording dimensions and lead position for mush coils.

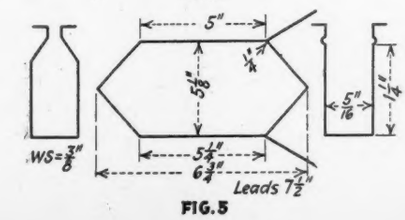
Fig. 1 shows a skeleton diagram that can be made up as a rubber stamp and filled out as required. Fig. 2 shows the diagram in Fig. 1 filled out for a flat, diamond-mush coil with leads at the diamond point. Fig. 3 is filled out for a flat, rectangular mush coil showing the position of the leads. Fig. 4 is filled out for a flat mush coil of a basket winding, showing the diamond points off the center line of the coil. Fig. 5 is filled out for a flat, diamond-mush coil for a d.c. machine having the leads at the end of each slot side. Fig. 6 shows a diagram providing for dimensions when the center of the diamond points is off the center line of the coil.

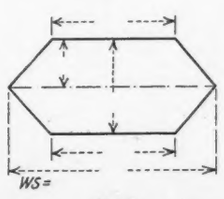












WINDING TAG

Order No. Xy-9682
Customer John Doe Co.
No. Coils 48 Mould No. 18
Type Mush Ins. —
Size Wire #17 S.C. and En
Turns Per Single Coil 27
Coils Wound From No. 2 Reels
Color Sleeving 1 Wires Per Sleeve 2
Leads Start 4 Finish 4
Notes Tape ends 3/4"

Fig 11

WINDING TAG

Order No. 4200
Motor No. 60 Series No. 1278910
Type XT Make MR
H.P. 5 Volts 220 Amp. 13.1 Phase 3
Cycles 60 R.P.M. 1750 Poles 2
Conn. Series Y Pitch 1 and 11
No. Coils 24 Mould No. 6
Type Bkp Ins. —
Size Wire #15 S.C. and En
Turns Per Single Coil 4-3
Coils Wound From No. 2 Reels
Color Sleeving 2 Wires Per Sleeve 1
Leads Start 6 Finish 6
Notes Tape all around .0045 x ½ cotton — Don't dip

Fig. 12

Fig. 11—Winding card containing coil information for commercial repair shops where a variety work is done. Fig. 12—A similar winding card for use in an industrial plant repair shop.

Both of these cards are filled out to show the data that would be recorded for a particular job.

The systems described in the above articles cover the subject and the following will add a few more practical points. Fig. 1 shows a diagram that can be used for all flat, mush-wound coils regardless of lead position or whether the coils are diamond-shaped or rectangular. This diagram can be made up as a rubber stamp and the sketch stamped on 3-in. by 5-in. or 4-in. by 6-in. cards, or on forms carrying other motor rewinding data.

The sketch of the partially closed and open slot can be filled in to give the slot size. The letters *W.S.* indicate wire space, and is the thickness of the center block of the mold. The other dimensions necessary for flat mush coils are, length of cells or slot portions of coil, total over-all length, width or coil pitch in inches, location of diamond point and radius used at corners of mold, wire space and location of and length of leads.

Fig. 2 shows the diagram in Fig. 1 filled in for a flat, diamond mush coil with leads at the diamond point. This coil is used for a partially-closed slot machine, the slot opening being ⅛ in., with the radius in corners ¼ in. *W.S.* is ½ in. and the length of leads 4 in. The one dimension for the coil width indicates that the diamond points *A* are on the center line of the coil. The letters *A* are not included in the coil data. They have been used in this case to illustrate the point referred to.

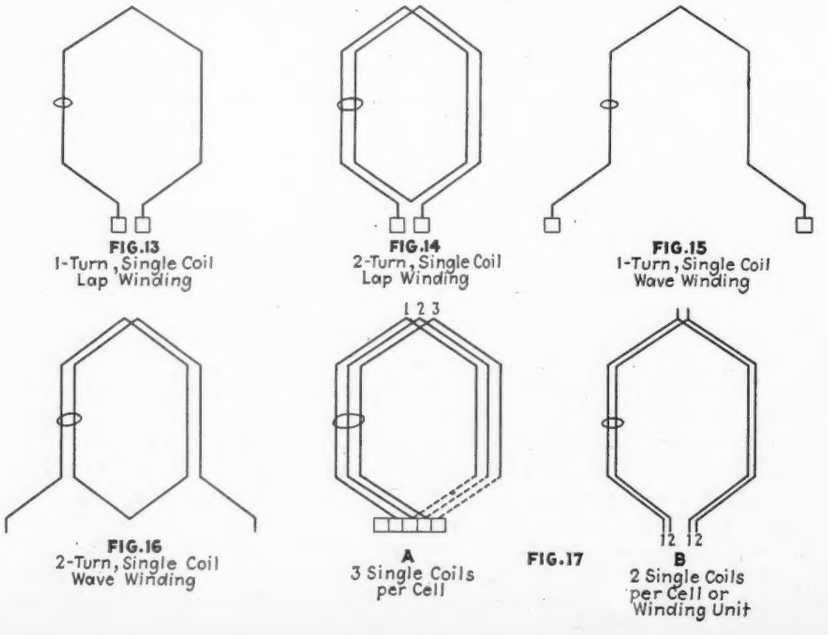
Fig. 3 shows the diagram of Fig. 1 filled in for a flat, rectangular mush coil, such as is used in d.c. bipolar machines using the staggered winding. Note the two straight lines that have been drawn across the coil width, and the position of the leads. In this case the over-all length is not filled in as the cell lengths are also the length of the mold, as shown.

Fig. 4 shows the same diagram filled out for a flat mush coil for a basket winding. Note the method of locating the diamond point, which is off center ¾ in., and the location of the leads between the long cell and diamond point. In this type of coil, which is used in basket windings for stators, the long cell is the bottom cell. This is just the reverse in two-layer windings, the reason being that the bottom of the basket coil must be bent down to allow the top coils to clear.

In Fig. 5 the diagram of Fig. 1 is filled out for a flat, diamond mush coil for a direct-current machine having the leads at the end of each cell.

A slightly different diagram is shown in Fig. 6, which provides for off-center diamond points and does not include the slot size sketch. This reduces the cost of the stamp and permits the use of a smaller card.

Fig. 7 shows a diagram used for mush coils of the concentric-chain type, such as are used in single-phase motors, etc.



Figs. 13 to 17—Diagrams showing different types of single coils as used in lap and wave windings.

Fig. 13 shows a one-turn single coil for the lap winding of an a.c. or d.c. machine. Fig. 14 is a two-turn, single coil for a lap winding. Fig. 15 is a one-turn single coil for a wave winding. Fig. 16 shows a two-turn single coil for a wave winding. Fig. 17 shows a winding unit composed of three single coils and one or two single coils per cell. The small circle surrounding one coil side indicates that the conductors enclosed are all in the same slot.

Fig. 18—This form provides a means of recording complete coil and armature winding data.

The top part of the form is filled out as it would be in a particular case.

Fig. 8 shows the same diagram except it has a table providing for the recording of six different sizes of coils. This is a better diagram than Fig. 7 when this type of coil has a number of different sizes of coils per group. The last column indicates the number of coils of each size required.

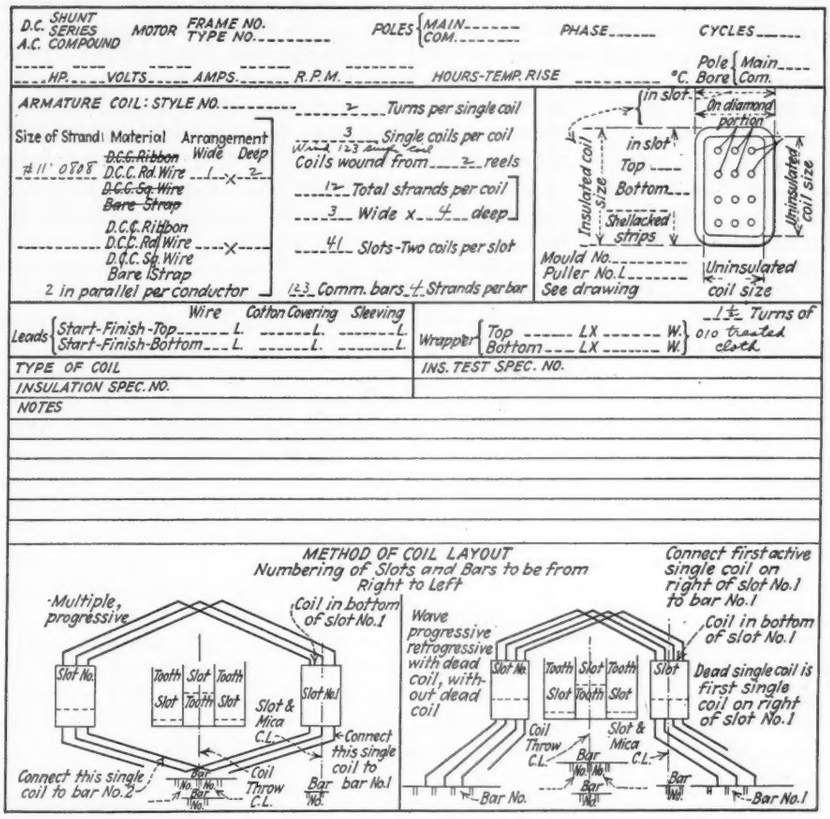
In Fig. 9 a diagram for mush, pulled coils is shown. The part *A* is similar to Fig. 1. The loop *B* is for recording the length of the loop over the outside of the pins, and also the diameter of the pins, at *D*. At the right of this diagram the notation is used to indicate the lead position, whether the coils are right- or left-handed, and also whether the long cell is on top or on the bottom. By crossing out the words not wanted, this notation can be used in all cases.

In Fig. 10 the diagram of Fig. 9 has been filled in for a left-hand rotor coil with leads on top and long cell on top, with the leads brought out from the end of each cell. Note the way the leads are shown both on the loop and the pulled sketch. The over-all length of 8 in. is measured from inside edge of diamond point.

Fig. 11 shows a winding card suitable for commercial repair shops. The reverse side can be used to give coil dimensions, by using the diagrams in Figs. 1, 6, 7, 8, or 9, according to the type of coil needed. Fig. 12 shows a winding card that will be found useful in the winding department of repair shops in industrial plants. This differs from Fig. 11 in that the motor data are given, and also the connection and coil pitch.

The card in Fig. 11 is shown filled in for a flat, diamond-mush coil. The data indicate that the coils are wound with 27 turns of two No. 17 s.c.e. wires in parallel. The number of reels gives the number of wires in hand. The wires per sleeve is also the number of wires in parallel per single coil. The number of colors of sleeving is a multiple to use to determine the total number of single coils. In this case it is, 24 coils $\times$ 1 = 24 single coils. In Fig. 12, 24 coils are shown and two colors of sleeving or, 24 $\times$ 2 = 48 single coils or bars.

Fig. 12 is filled out for a flat mush coil having 48 single coils. In this case 24 single coils are wound with four turns and 24 single coils with three turns, there being two wires in hand and one wire in parallel per single coil. The three and four turns are obtained by winding three turns with two wires in hand, and



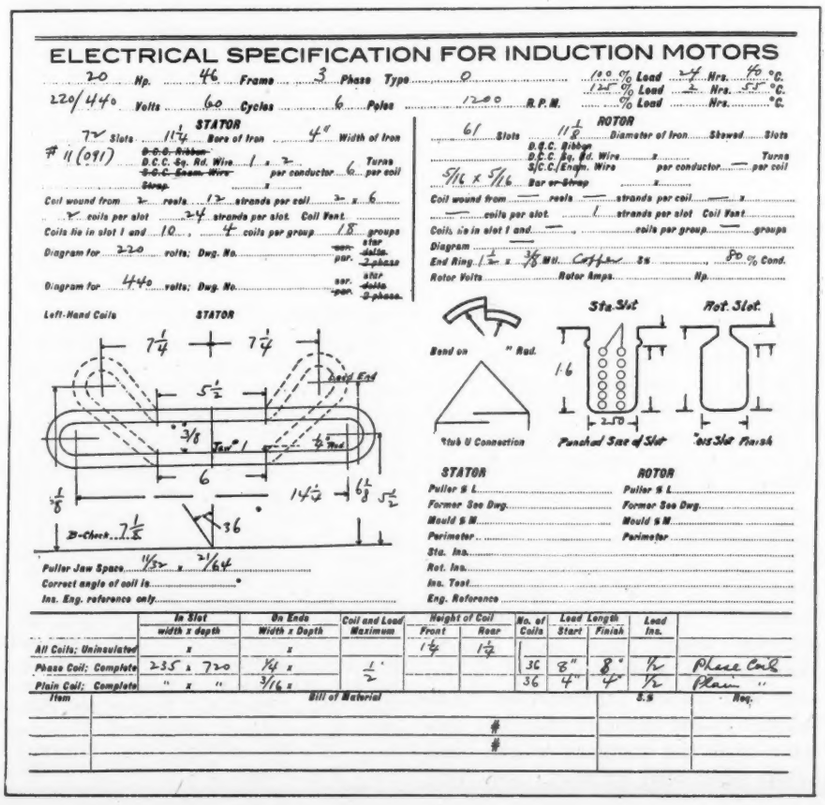


Fig. 19—This form provides for all necessary data needed in connection with induction motor coils and types of windings.

The form is filled out for a 220-440-volt winding on a three-phase, 60-cycle, 1,200-r.p.m. induction motor.

then cutting one wire and putting on the fourth turn with one wire. A red sleeve should be used for the start and finish of the four-turn coils. This enables the armature winder to connect the leads to the commutator in the proper sequence: namely, 3, 4, 3, 4, etc.

Before describing other types of mush coils, winding terms and methods of checking them will be defined.

Conductor—This will be considered as a single wire or bar. A conductor may also be composed of a number of adjacent wires or (strands) in parallel. For example, a flexible cable consisting of 40 No. 19 wires is a conductor, and each single No. 19 wire is a strand; or the cable is a conductor having 40 strands in parallel.

It is important to get the full meaning of the term conductor, since this represents the total current-carrying medium of any one single coil. This conductor may be a single round or square wire, a ribbon wire or a number of wires in parallel; hence the reason for expressing the conductor for each single coil as the number of wires per sleeve.

Strand—This can be defined as a single unit or wire of a conductor. Consider a single coil wound with 15 turns of three No. 14 d.c.c. wires in parallel. In this case the conductor is three No. 14 wires and the strand is one No. 14 d.c.c. wire.

Single Coil—This can be defined as any one coil having one or more turns of any size conductor. Fig. 13 shows a one-turn, single coil for a lap winding, a.c. or d.c. Fig. 14 shows a two-turn, single coil for a lap winding, while Fig. 15 shows a one-turn single coil for a wave winding, and Fig. 16 shows a two-turn single coil for a wave winding. The small circle surrounding one coil side indicates that the conductors enclosed are all in the same slot.

From the rules given above it should be understood that a single coil can be wound as 27 turns of two No. 14 wires in parallel, or the coil can be wound from two reels, with two wires per sleeve. If the winding data read "27 turns, No. 14 d.c.c. wire, coils wound from two reels, one wire per sleeve," this would mean that we have *two single coils* per cell or winding unit and that each single coil consists of 27 turns of one No. 14 d.c.c wire. This brings us to the meaning of the term "winding unit."

Winding Unit—The winding unit, or number of single coils per cell, may be defined as consisting of a number of single coils assembled or wound together. This group of single coils is taped together so that the armature winder handles a number of single coils as one unit; hence the term winding unit, or single coils per cell. Fig. 17*A* shows a winding unit composed of three single coils, and Fig. 17*B* shows a winding unit of two single coils per cell.

Fig. 18 shows a form suitable for recording complete coil and armature winding data. The sketch in the upper right-hand corner is used to indicate the arrangement of the wires in the complete winding unit, as well as to give the uninsulated and insulated coil sizes. The data as filled in are self explanatory.

The section for leads uses the terms, "start, finish," and "top" and "bottom." This ties in the coil winder's terms with the armature winder's terms for the coil leads. The coil winder thinks of leads as starting and finishing ends while the armature winder thinks of these as top and bottom leads.

Thus, when the coil man is checking the first coil made for the armature winder, if the top lead is too long he knows that this is his starting lead, etc. This form can be used to give complete data on d.c. machines and for single-phase, commutator, series-type armatures.

Fig. 19 shows a form suitable for recording induction motor coil and winding data.

Another section of this article, to appear in an early issue, will deal with methods for winding and shaping mush coils.

Using Non-Metallic Gear Drives

(Continued from page 553)

determine the laws governing the behavior of non-metallic gear teeth so that a formula for use in computing designs can be worked out. Another advantage, irrespective of the strength, is the increased life of both the non-metallic pinion and its mating gear, due to decrease in wear.

The accompanying illustration on page 550 gives a fair idea of the standard construction of non-metallic gearing which has been recommended and generally adopted for gear and pinion construction. The keyway is cut through the gear material with the endplate, where used, as an additional support. On light service the endplate is not necessary. On gears made up of compressed layers of fiber the flange or endplate extends entirely to the tip of the teeth, as is the case with rawhide pinions. Idler gears are bushed. Gears cut from solid board do not require support at the tip of the teeth.

All of these fabric-base, non-metallic gears may be used for practically any industrial service within their rating. Reversing service is probably the most severe and before using them on such service it is advisable to consult with the manufacturer of the product and obtain his advice. Also, it is undesirable to have two non-metallic gears mesh together as it is not only unnecessary, but is uneconomical from a cost standpoint. Both gears wear more rapidly than when in contact with a metallic, cut-tooth gear.

The manufacturer of these products will give instructions for machining the gear teeth, that is, cutting speeds and so on, and will also furnish tables showing the recommended rating per inch of face for gears of various pitches and number of teeth of different peripheral speeds in feet per minute. These tables are too long to be reproduced here.

Fabric-base pinions must be lubricated with practically the same frequency as is necessary for metal-to-metal gears. For this purpose a paste composed of 20 per cent graphite and 80 per cent liquid shellac or a stiff paste of graphite and vaseline or machine oil is recommended. Any good graphite grease will be satisfactory if its viscosity is sufficient to maintain a film over the surface of the tooth. One manufacturer has put out a self-lubricating, non-metallic gear material which it has graphite impregnated in it.

EDITOR'S NOTE: Acknowledgment is made to the following companies for illustrations and information used in the preparation of this article: Bakelite Corp., New York; N. Y.; Boston Gear Works, Norfolk Downs, Mass.; Continental Fibre Co. (Contex), Newark, N. J.; the Chicago Rawhide Mfg. Co., Chicago, Ill.; Diamond State Fibre Co. (Celoron), Bridgeport, Pa.; Fibroc Insulation Co. (Fibroc), Valparaiso, Ind.; Foote Bros. Gear & Machine Co., Chicago, Ill.; Formica Insulation Co. (Formica), Cincinnati, Ohio; General Electric Co. (Fabroil, Textoil, and Textolite), Schenectady, N. Y.; Horsburgh & Scott Co., Cleveland, Ohio; National Vulcanized Fiber Co., Wilmington, Del.; and Westinghouse Electric & Mfg. Co. (Micarta), East Pittsburgh, Pa.

I'm looking for information and I'm willing to pay for it*

THERE is an old saying to the effect that, so far as his life work is concerned, no one can stand still—he must either progress or go backward. This is just another way of saying that when one stops going forward he starts to go backward, and the truth of this applies to business organizations and nations fully as well as to individuals.

Consequently, it is a good thing to sit down occasionally, say once a year or so, and sort of take stock of ourselves both as to our personal affairs and from the standpoint of our accomplishments as busy men who have very definite and indispensable duties to perform in the operation of that enormous machine which we call Industry.

Every year we spend many millions of dollars for new equipment to build new plants, increase production, or replace damaged or obsolete equipment. At the same time we are constantly testing and experimenting to find the best tools and methods of accomplishing certain desired results. And so the end of each year finds, or should find, us a little closer to our goal, and with a greater stock of information based on the results of our work. Furthermore, each of us has learned a good many things that other operating men would like to know, and could use to good advantage.

I want to find out what you have been doing and the results you have obtained; so the Editors have authorized me to offer several prizes for the best records of accomplishment.

Here's the story

EVERY reader of INDUSTRIAL ENGINEER is invited to tell what he has done within the past two years to cut operating and maintenance costs, improve operating conditions, solve operating problems, increase production: in other words, what worthwhile improvement have you made and what are the results obtained from it?

A first prize of $50 will be paid to the one who sends in what the Editors consider is the most helpful and striking record of what has been done. A prize of $25 will be given for the next best account, and a prize of $15 for the third. Letters which do not win prizes will be considered for publication at our regular rates.

IN JUDGING the manuscripts neither length nor style of writing will be considered, nor will the amount of savings made necessarily be the deciding factor. The awards will be based on the general value of the results obtained, from the standpoints of the savings made and the improvement in operating conditions, the soundness of the idea, the ingenuity with which it was conceived and executed, and its applicability to other industrial plants.

For example, you may have improved operating conditions by changing from individual drive to group drive, or *vice versa*, or made a saving by replacing obsolete electrical or mechanical power drive equipment with more modern and efficient devices that reduce labor and require less maintenance.

Perhaps you have saved time and money by eliminating troublesome and expensive production delays due to poor or improperly applied operating equipment.

Again, you may have cut maintenance and repair costs by putting in better testing and repair equipment, so that you can detect troubles before they become serious, and do better repair work.

Or possibly you have effected worth-while economies by changing your methods of scheduling and handling the work, so that a better job can be done with greater efficiency.

These are only a few of the ways in which plant operation has been improved and operating costs reduced.

Make your story brief and concise, but go into enough detail to show clearly what the previous conditions were, what changes were made, the cost of these changes, the savings made, and the general nature and value of the results obtained. If you can send photographs to illustrate your story, do so. The contest closes Jan. 7, 1927. Address all letters to Contest Editor, INDUSTRIAL ENGINEER, McGraw-Hill Publishing Company, Tenth Ave. at 36th St., New York, N. Y.

HERE is a good chance to win a prize and help other plant men by giving them the results of your experience in solving important problems that are of mutual interest. Check over what you have accomplished and then send in your story—NOW.

Practical Pete

***$50 for the best record of accomplishment.**
$25 for the next best record.
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G. A. VAN BRUNT, *Managing Editor*

Light Utilization Has Lagged in the Parade of Progress

IF WITH one eye we view in our imagination the tremendous improvement in light production during the past century and with the other eye we view the progress in light utilization, it becomes evident that the former has outstripped the latter. As much light can be purchased now for one or two cents as could be bought a century ago for a dollar, assuming no change in the purchasing power of money. On this basis the workman should have at least 50 foot-candles upon his work today, for his predecessor a century ago certainly had no more than 1 foot-candle. (The latter would be the illumination supplied by an ordinary candle upon a surface one foot distant and perpendicular to the direction of the light rays.)

As a matter of fact the average worker of today is supplied only a few foot-candles. The purchasing power of money is now only a fraction of what it was a century ago. Furthermore, the standards of living and working are at present much higher than they were a hundred years ago. These last two reasons might well demand an increase of five or ten times in the quantity of light upon the work.

Taking all these factors into consideration we might conclude that work places at the present time should be illuminated to an intensity of several hundred foot-candles, if lighting is to have its proper place in the parade of progress.

There would be no point to this argument if lighting indoors were up to the level which is economically possible and optically desirable. However, it is far below the best level, and its progress has been inhibited by a lack of appreciation of the foregoing. The situation is the more inexcusable because it has been definitely proved that good lighting not only pays for itself in greater production, reduced spoilage, increased safety, and better morale, but, in addition, usually pays very good dividends.

Money Well Spent May Be Money Saved

IN THEIR attempt to make what they consider is a "good showing," operating executives sometimes fall into the error of hesitating, or refusing, to spend any money for new equipment or other betterments until it becomes absolutely necessary to do so. Frequently the management either fosters or is responsible for this attitude.

However it originates, the inevitable result is that obsolete or worn-out equipment is patched up and carefully nursed along year after year in the effort to keep it in service long after it should have been junked. When compared to the price of a new piece of equipment, the cost of one repair job may not be very large. Nevertheless, when the total cost of the maintenance attention required over a period of two or three years is added up, the result may be interesting, if not pleasing. Furthermore, this does not take into consideration the cost of production delays that have been occasioned by shutdowns due to failure of the equipment, nor the savings in labor or increases in production that could be made without difficulty by the use of up-to-date and more efficient devices.

True economy in the expenditure of time, money, labor or any other thing of value is highly commendable and should be practiced at all times. However, refusal to spend money for new equipment that will save labor, increase production, or cut operating and maintenance costs is by no means economy. Nor does the way of economy lie in neglecting equipment now in use until failure makes extensive repairs imperative.

The most expensive man around a plant is not necessarily the one who spends the most money in discharging his duties properly. In the long run, the most expensive man is likely to be the one who causes his employer to spend a dollar, while he is trying to save 75 cents by neglecting to keep the equipment under his care in good condition, or continuing to operate it after it has outlived its period of real usefulness and becomes a liability rather than an asset.

Are You and Your Men Taking Advantage of the Public Library?

RECENTLY, a prominent plant engineer who has a force of several hundred men under his general direction stated that so many of his men stop studying and learning more about their work that he has difficulty in obtaining a properly trained supervisory force with sufficient technical knowledge.

This executive, like many others with a similar problem, encourages his men to take correspondence or night school work and to read the technical or trade journals and books covering their activities and industry. As a result, practically every man who has had a technical education or two years of correspondence or night school work has the equivalent of a foreman's position, or better.

In addition to these schools the advantage which the local public library offers should not be overlooked. Practically all of our cities and industrial centers have public libraries whose resources are free to all and which offer a path to education that need not exclude any other activity, but which may accompany it and make it more valuable. Self-education by this means need not be pursued in any set or rigid form, but may be obtained as fast or as slowly as each individual desires, or time

and energy permit, and be as specialized or general as needed.

One of the important directions of growth of the public libraries of our cities has been in the development of scientific, technological and economic divisions. These departments are, in many cases, staffed by technical experts. The public library can be a valuable guide to the modern worker and executive seeking an acquaintance with those fields of knowledge essential to an understanding of, and wide participation in, our industrial society of today.

There are, of course, many books and periodicals which these men should receive and own, but much special information is often required for reference that the average man needs and does not feel that he can afford to purchase.

The thinking operating executive who is looking to the future will do well to call this source of free information to the attention of his staff, and may find that he, too, can use it profitably.

Make a Plant Engineer Responsible for All Equipment

THE vice-president of an old and nationally-known organization recently made the following statement: "A few weeks ago I hired a Plant Engineer and have given him complete charge of the electrical and mechanical equipment in our plant. I am paying him a mighty good salary, but if he does not pay his salary twice over in savings, I shall be very much surprised. A Plant Engineer is one of the best investments that any plant can make."

The executive whose words are quoted above has come up through the operating end, and made an enviable record in the capacity of Plant Engineer for several large firms, before his present connection. His views on plant operation can be accepted as those of an authority.

Every industrial plant of any size contains a large amount of electrical and mechanical equipment that must be inspected, kept in good condition, and occasionally shifted around. Every year a certain amount of this equipment has to be replaced, for one reason or another. Again, in most plants new equipment is continually being purchased to increase productive capacity.

All this work naturally brings up a thousand and one operating problems and questions that must be investigated and answered correctly, or trouble and loss of efficiency will be the result. In addition to this more or less routine work, there is a constant need for special investigations and studies bearing on the application and operation of equipment under the conditions obtaining in each plant.

No executive who is trying to handle all of these details along with other important work can hope to make a good job of it. Nor does the rather common practice of making one man responsible for the electrical equipment and another for the mechanical, always work out to the best advantage.

Shifting of responsibility and arguments arising from the conflict of individual preferences and opinions do not make for high operating efficiency and freedom from serious operating troubles. These conditions can be avoided, however, by centering responsibility for all equipment in one man, and holding him accountable for operating results.

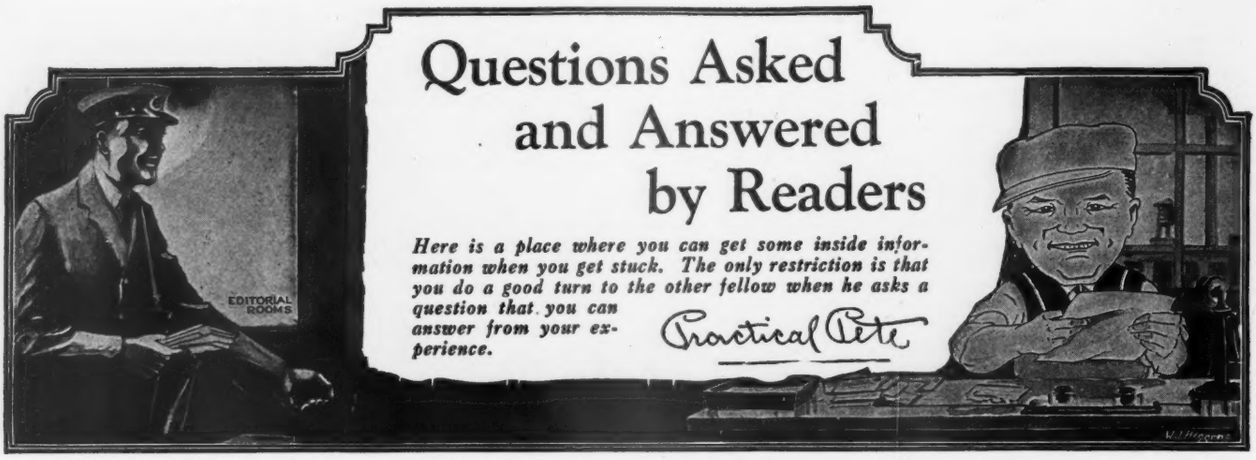
Building a Force of Assistants for Future Plant Programs

IN REPLY to a question on how he quadrupled his force within a few months, the Electrical Engineer of one large industrial plant recently said:

> Each of my assistants in charge of the different construction and maintenance gangs has been promoted from the ranks. Several years ago I saw that, eventually, the entire plant must be reconstructed, which would mean a lot of work for my department over a period of several years. To have a supervisory force trained in our methods and practices when that time came was my big problem. Therefore, I encouraged the men to take up night or correspondence school work, and urged the technically-trained men in my department to pursue their studies further. The most promising individuals were shifted about, to give them wider experience.
>
> In addition, each man was urged to ask questions on anything he did not understand, and to offer suggestions on his work. My first assistant or I held frequent conferences with these men on general subjects and would even stay after hours to explain technical questions or company problems, when the explanation would be too lengthy to give during working hours or was of particular interest to only one or two men. Especially were we careful not to create that high and mighty attitude of superiority which some so-called executives think is so necessary to preserve their dignity.
>
> In other words, our problem was not to demonstrate that we were boss—the men knew that—but to help and encourage them to do and learn more. Our method has evidently proved successful because these men are most enthusiastic in carrying on for us and we are getting the work done the way we want it, which might not be the case if it had been necessary to obtain foremen and other assistants from the outside.

There is a good deal to think about in the words of this plant executive. First, the true executive carefully distinguishes between having men work *with* instead of *for* him, and he recognizes that this is obtained only through his attitude toward the men. Also, many other industrial plants must face similar problems of rehabilitation to bring an old plant into shape to meet present-day competition.

Industrial operating executives upon whom this task will fall should be laying their plans for this work, with particular attention toward how they are going to build their force. Wire, conduit, motors, belts, pulleys, line-shaft and the other supplies necessary can be purchased when needed. The men who are to supervise the details of these rehabilitation programs cannot be so easily obtained. The best are usually developed through careful training and coaching in the plant in which they are working.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

Rotor Winding of Slip-Ring Motor—I am changing the stator winding of a 35-hp., wound-rotor induction motor from three phase to two phase. Will it be necessary to rewind the rotor of this motor? If so how should I go about laying out the new winding and what form should it take? If it is unnecessary to change the winding, please tell me the reason therefore.
Los Angeles, Cal. B. K. W.

* * * *

Type of Valve Best Suited for Long Service.—I would like to know whether a gate valve, a globe valve, or a changeable disk valve is best suited for long service when used in the following applications: (1) Cold water at ordinary water pressure. (2) Low-pressure hot water. (3) Low pressure steam. (4) Steam at pressures ranging from 100 to 250 pounds. I will greatly appreciate any information that readers may give me in this regard.
Ilion, N. Y. M. M.

* * * *

Effect of Altitude on Capacity of Generators.—Will some reader tell me the effect of altitude above sea level on the capacity of electric generators? We often contract to install electrical apparatus at altitudes of about 12,000 ft. above sea level and would like to know how much the generators should be derated. The A.I.E.E. Standardization Rules specify derating in regard to temperature guarantees, but we would like to know the equivalent in capacity as expressed in kw. or kva. rather than in temperature rise.
Lima, Peru. A. B.

* * * *

Manipulation of Wire Cables—I am in charge of the electrical and mechanical maintenance of a large plant and because of this I have considerable to do with the elevators in the plant buildings. I feel the need of more information regarding the manipulation of wire cables as used on elevators, hoists, and cranes. Specifically, I would like detailed information on how to go about recabling an elevator or crane hoist, including directions for shackling, seizing, and resocketing. Any hints or kinks that readers can give me regarding the methods of handling steel cable around the equipment mentioned will be very much appreciated.
St. Paul, Minn. D. H. C.

* * * *

Method of Removing Wires From Semi-Closed-Slot Motors.—I shall appreciate it very much if some of the readers will tell me the best way to strip the stators of small series motors having semi-closed slots. I have seen a great many repair shops burn the insulation so that the wires come out easily. Does this in any way damage the iron or the insulation between the laminations? Can you advise me of a better method? Also, I should like to know the number of dippings and bakings that are necessary to make a first-class job on a motor.
Rome, Ga. M. S. C.

Heating of Fan Motor—I have rewound a 16-inch desk-fan motor, using a coil span of 1-and-3 instead of the former coil span of 1-and-6, and using the same number of turns, coils, and size of wire as formerly used. The motor now operates at a normal speed of 1,750 r.p.m., but becomes abnormally hot within a few minutes after starting. Most of the heat seems to come from the stator iron rather than from the coils themselves. What is the cause of this and how can it be corrected, keeping the present 1-and-3 slot winding? The motor is of the split-phase type, having four poles, 24 slots, and 24 coils with 58 turns of No. 24 single cotton-covered enameled wire per coil. It is rated at 110 volts, 60 cycles. The original winding had a coil span of 1-and-6, 83⅓ per cent pitch. I shall greatly appreciate any information that readers may give me on this problem.
St. Louis, Mo. T. A. B.

* * * *

Effect of Doubling Speed of Lineshaft.—We have a lineshaft operating at 250 r.p.m., driving a number of woodworking machines. I am considering doubling the speed of this lineshaft; that is, increasing it to 500 r.p.m. This will give a better belt drive from the motor to the lineshaft, as then I will not need to use so small a motor pulley. Also, a number of the pulley ratios from the lineshaft to the jackshaft will be changed, as I am going to increase the speed of most of the machines only about 30 to 50 per cent instead of doubling them. There is no noticeable vibration in the lineshaft at present. As nearly as I can determine from computations, however, the shaft is well loaded at the present time and I should like to know what the effect will be when I increase the speed, and whether I might have to put in a new shaft, assuming that the present shaft is carrying full normal load for its size and speed. I shall greatly appreciate any information that readers may give me on this problem.
Milwaukee, Wis. G. G. K.

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Can Two Single-Phase, Watt-Hour Meters Be Connected to Measure Three-Phase Power?—I should like to know whether two single-phase, watt-hour meters can be connected so as to measure three-phase power. If so, will some reader explain the method of connection to use. I have already connected these watt-hour meters in the same manner as is used with two single-phase wattmeters in the two wattmeter method of measuring power. With this connection I find that at unity power factory both meters run at equal speed, while as the power factor gets lower one meter will slow down and the other one speed up until at 50 per cent power factor one meter stops entirely while the other is running at double speed. If the power factor is lowered below 50 per cent the meter that has stopped will reverse and run in the other direction. I wish some one would explain the reason for this, and tell me why the meters are affected differently instead of being affected in the same manner. Specifically, I should like to know what takes place in each meter at unity power factor, at 75 per cent, at 50 per cent, and at 25 per cent power factor.
Montreal, Can. W. T.

Answers Received To Questions Asked

What Size of Belt Is Required for This Drive?—A 15-hp., 1,750 r.p.m. motor is used to drive a punch press. The pulley on the motor is 6 in. in diameter and the driven pulley is 40 in. in diameter, the distance between centers of the motor and press pulleys being 15 ft. I wish readers would give me some information regarding the adaptability of leather belts to this drive. Specifically, what width of leather should be used to give the best results? Should this belt be single or double-ply? Would you advise the use of some other type of belt and if so, what kind and why?
Rockford, Ill. R. W. A.

In regard to the question asked by R.W.A., handbooks state that under good conditions of operation a belt drive can be designed for an effective tension of 55 lb. per inch of width, in case a good grade of single leather belting is used. R.W.A.'s condition of service could not be classed as good, however, because the diameter of the shaft pulley is quite large compared with the 6-in. motor pulley. The ratio of the diameter of the two pulleys on a belt drive should not be greater than 6 to 1 for ordinary service. Therefore, a more satisfactory belt drive would result if it were designed by using a tension of 45 lb. per inch of width.

The size of belt to use is determined as follows: To calculate the belt speed for a pulley, multiply the diameter of the pulley in inches by 3.1416 and then multiply by the number of revolutions per minute of the pulley; this is to be divided by 12 to get the speed in feet per minute. Substituting in this formula the data as given by R.W.A.:

$$(6 \times 3.1416 \times 1{,}750) \div 12 =$$
2,750 f.p.m. approximately.

The width of the belt required to transmit 15 hp. is determined by the formula: $W = (33{,}000 \times \text{hp.}) \div (S \times E)$. Substituting gives $(33{,}000 \times 15) \div (2{,}750 \times 45)$ = approximately 4 in. as the belt width. In this formula hp. equals horsepower transmitted; S equals belt speed in feet per minute; E equals the effective tension in pounds per inch of width. I believe that a single-ply, 4-in. belt should be used because a double-ply belt would be too stiff to wrap well around the pulley. If a belt does not wrap well on the pulley, the effective pull is reduced and if loaded up to its full capacity it is likely to slip. E. E. SIGEL.
Robertsdale, Pa.

Without going into detail concerning the computations incidental to determining the proper size of belt for R.W.A.'s punch press drive I had estimated that a 4-in. single belt made of special, mineral-tanned leather should be used. The advantage of using special, mineral-tanned leather is that this material is highly elastic and yet does not slip, which makes it ideal for punch press work. Single-ply leather is usually preferable wherever it can be used because it will transmit more power per dollar of first cost, as well as having a lower ultimate cost.

However, I decided to ask a belt engineer for his opinion on this drive. He said that on a drive such as described there is considerably less than 180 deg. arc of contact on the 6-in. pulley. Also, the belt must be capable of withstanding the shock and acceleration encountered in punch press service. In addition, all motors are capable of carrying a 50 per cent overload so as to withstand these momentary shock loads. Therefore, he states that it stands to reason that a 4-in. single belt is out of the question and that nothing less than a 5-in. double belt should be used. I believe that these two opinions will indicate to R. W. A. the difficulty incidental to specifying a belt drive according to book formulas without considering the operating service.

Newark, N. J. W. F. SCHAPHORST.

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In his question R.W.A. has not given complete data and consequently in discussing it, it is necessary to assume certain factors; namely, that the drive is horizontal and the tight side is on the bottom strand.

The first comment we would then make is that the 15-ft. center distances is certainly maximum for the width of belt which would be required. Also, the pulley ratios are high. The 6-in. driving pulley is small for the drive and so does not give a large amount of belt surface in contact on the driving pulley. Because of the operating characteristics of the punch press, other concessions, or allowances, are necessary also.

Our recommendation for the belting of this drive would be a 6-in. double leather belt, approximately 16/64 in. thick. In suggesting this width of belt, the efficiency correction for the drive and the overload capacity of the motor, as well as the operating characteristics of punch presses. are taken into consideration. CLAUDE O. STREETER.

Mechanical Engineer,
Graton & Knight Co.,
Worcester, Mass.

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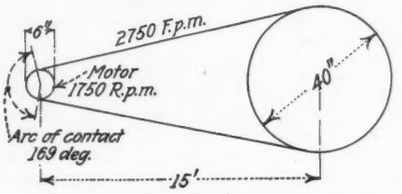
The accompanying drawing shows the transmission layout for R.W.A.'s punch press problem, in which he asks about the drive leading from the motor. The exact location of the motor, whether on floor, ceiling or a wall bracket, does not affect the case. [NOTE: Where the center line of the drive is at an angle of over 40 deg. from the horizontal allowance must be made in computing the power transmitted, particularly when the small pulley is located below. — EDITORS.]

Two methods of obtaining the solution are possible. The first, and simplest, is to use the width of belt for which the press pulley was intended. Thus, if the press pulley has a 7-in. face, a 6-in. belt would be installed. It is safe to assume that the maker of the press equipped it with a pulley of such size as would be ample to power it up to the safe capacity of the machine. Also, it was his duty to supply the press with a flywheel of such weight and diameter as would carry the peak load without undue slippage of the belt.



This shows the layout of the drive for a punch press, under the conditions given

The second solution is obtained in a more theoretical manner. A 6-in. pulley on a 1,750-r.p.m. motor drives the belt at about 2,750 f.p.m. That is a definite starting point and the other calculations have to do with that belt speed, the effective tension of a belt at that speed, and the arc of contact on the motor pulley. Every handbook and practically all belt makers' catalogs give tables from which this data may be selected, once the layout has been plotted as per the accompanying drawing and the belt speed determined by calculation.

Formulas will obtain the same results but are somewhat slower than the use of tables. The following discussion contains the answer to the problem without going into methods.

The allowable "effective tension" for a belt at 2,750 f.p.m., as given in my tables, is 67 lb. per inch of width, when the arc of contact on the small pulley is 180 deg. The effective tension is the pulling power of the driving or tight side of the belt minus the tension in the loose side. This tension should not be so high as to stretch the fibers to any serious degree. By tables or formulas, the arc of contact on the motor pulley is found to be only 169 deg. and this lessens the grip of the belt. So, taking the factor for 169 deg. (which is 0.97) the safe effective tension is 0.97×67 lb., or 65 lb. per inch of width for ordinary 16- to 18-oz. single-ply leather belting of good grade.

From the above data, the width of belt to use is easily determined by the formula which gives the width as the result of dividing the product of the horsepower and 33,000 by the product of the effective tension and the belt speed. The result in this case is 2.75 in.; hence, a 3-in. belt could be used.

Insofar as the kind of belt to use is concerned, the best of satisfaction, I believe, would be obtained from a first-quality leather belt. If this be't is not cut from the plant stock, the purpose for which it is to be used should be stated when ordering the belt. Probably a belt maker would recommend a wider belt, say 3½ or 4 in. It is better to be over-belted than under.

The data given for the problem are rather insufficient. Just why a 15-hp. motor is used is not stated. It may be that this is a spare motor on hand, or perhaps the manufacturer of the punch press recommended that size. If the machine is a new one, undoubtedly the motor size has been given and all related parts are adapted to the work. If the punch is second hand, there may have been alterations in flywheel and pulley sizes that would make a good deal of difference in the size of belt required.

If the stroke of the punch were given, with information on the amount of work, whether cutting or forming and what size, then it would be a simple matter to check up the flywheel size and speed and see if it were carrying its share of the belt's load.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

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The problem confronting R. W. A. is a good example of where an allowance must be made for the peak load or overload. I would say that a 4-in. double leather belt of second-quality leather would be good enough. A 6-in. pulley at 1,750 r.p.m. gives a belt speed of approximately 2,800 f.p.m. A load of 15 hp. can be transmitted at a belt speed of 2,800 f.p.m. and with pulley ratio of approximately 1:7 by a first-quality single ply leather belt 4 in. in width.

However, as the 40-in. pulley is large and heavy the strain on the belt comes when starting the machine, and for this reason I believe that a double belt would be better than a single. A belt should be chosen which has good adhesion because it would be needed to prevent slipping when starting the heavy press.

R. W. A. can obtain a copy of a celluloid speed chart of the slide-rule type which answers this and similar problems providing that the man who works the chart will take into consideration and make allowance for overloads and peak loads. This chart may be obtained from the Leather Belting Exchange, Philadelphia, Pa., or from any leather belt manufacturer who is a member of the Exchange.

Also R. W. A. can solve his problem by using the two charts which were published on page 270 of the June, 1925, issue of INDUSTRIAL ENGINEER. If he does not have a copy of this issue on file, he will find the same table in Bulletin R-13, published by the Leather Belting Exchange, Philadelphia, Pa., which is also available from leather belt manufacturers who are members of the Exchange. By consulting the charts opposite page 24 in Bulletin R-13, he will see that a light double belt at 2,800 f.p.m. transmits 6.53 hp. per inch of width. Because of the operating conditions this would have to be multiplied by 0.74 as a factor which gives the actual rating under these conditions of 4.8 hp. per inch of width. It would not be necessary to

use the best quality of leather belt (which is cut from the hide in the section next to the backbone), as second-quality leather belt (cut from strips next to the first-quality belting) will have a power-transmission capacity of 19.2 hp. for a 4-in. belt, which is plenty to allow for the peak load. In addition, this belt would have an overload capacity of at least 50 per cent or more. We do not believe that a high-priced belt would be absolutely necessary on this drive as long as it is of good quality double leather. J. R. HOPKINS.

Chicago Belting Co.,
Chicago, Ill.

* * * *

R. W. A. could use the following short, practical method of determining the width of a leather belt required for a given horsepower which, however, does not take into consideration the centrifugal force on high-speed belts. Single leather belts 1 in. wide operating at 800 r.p.m. develop 1 hp. with a belt contact of a 180 deg. on the pulley. On this basis the width W equals: $W = (\text{hp.} \times 800) \div (V \times K)$, where hp. = horsepower of motor or power to be delivered; V = speed of belt in feet per minute; thus, $V = (1{,}750 \times 6 \times 3.1416) \div 12 = 2{,}750$ f.p.m. approximately. K = factor depending upon arc of contact taken from the accompanying table.

Belt Contact Degrees	Factor K
×180	1.0
×157.5	0.92
×135	0.84
112.4	0.76
90	0.64

The arc of contact A is obtained approximately by the formula: $A = 181 - [60\ (D\text{-}d) \div L]$; where D = diameter of large pulley in inches; d = diameter of small pulley in inches; and L = distance between pulley centers in inches. Therefore, $A = 181 - [60 \times (40\text{-}6) \div 180] = 169.7$ deg. The nearest value of K from the table is 0.92. Then $W = (15 \times 800) \div (2{,}750 \times 0.92) = 4.73$ in. A 5-in. belt would be used.

Oak-tanned leather belting is most generally used for driving punch presses. Although better results are obtained by using narrow, thick belts, as compared to wide, thin belts, it is not advisable to operate double belts around pulleys less than 12 in. in diameter. E. H. LAABS.

Engineering Department,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

* * * *

The following is my solution of R. W. A.'s problem. The first step is to determine the speed of the belt in feet per minute by the formula: (3.14 × diameter of pulley in inches × r.p.m.) ÷ 12 = (3.14 × 6 × 1,750) ÷ 12 = 2,748 f.p.m., or approximately 2,750 f.p.m. The next step is to find the arc of contact of the belt on the smaller pulley thus: 180 — 4.75 (difference in diameter of pulleys in inches ÷ center distance in feet) = 180 — 4.75 × (34 ÷ 15) = 180 — 10.69 = 169.31 deg. or approximately 170 deg.

The allowable effective tension per inch of width of single and double belts of different thicknesses, with 180-deg. arc of contact as taken from the "Standardized Belt Manual," Bulletin 102, issued by The Graton & Knight Mfg. Co., Worcester, Mass., is given in the following table.

Single Leather Belts

Thickness in 64th of of an in.	Effective Tension in Lb. per in. in width
7–10	44
10–12	49.5
12–14	44

Double Leather Belts

16–18	70.4
19–21	79.2
22–24	88.

The problem now consists of selecting a weight or thickness of belt which my experience would lead me to believe is satisfactory for this drive, and then checking this selection by substituting the value of the tension and other data in the formula to determine width.

From my experience I would assume that a 12-14/64-in. single leather belt could be used. The allowable effective tension is 55 lb. per in. in width with 180-deg. arc of contact. A smaller arc would permit less effective tension. In this case the usable effective tension would be approximately 55 × (170 ÷ 180) = 51.9 lb.

The width of such a belt is determined by the formula, Width = (33,000 × horsepower transmitted) ÷ (effective tension in pounds per inch of width × speed of belt in f.p.m.) = 33,000 × 15) ÷ (51.9 × 2,750) = 3.48 in. wide. I would use a 4-in. single leather belt 12-14/64 in. thick. I do not know the width of the pulleys, but if they could take a wider belt it might be well to repeat the computations with a thinner single belt because the thin belt would work more satisfactorily over the small pulley. The belt should be at least 1 in. narrower than the face of the pulley.

The Graton & Knight "Standardized Belting Manual" gives many helpful rules and formulas on leather belts and belt drives. W. P. IWEN.

Iwen Box & Lumber Co.
Pine Island, Minn.

* * * *

In reply to the question of R. W. A. I offer the following solution: Correct belt application depends upon several factors; namely, speed, thickness, width, the arc of contact between the smaller pulley and the belt, the material of which the belt is made, and the kind of pulleys employed. The speed of a belt for ordinary purposes should range from 3,000 to 5,000 f.p.m. The operating speed in this case is determined by the formula: (3.1416 × $d \times s$) ÷ 12, where d = diameter of motor pulley, and s = speed in r.p.m. of motor pulley.

For rugged service with 15-ft. pulley centers a double belt is preferable to a single belt. The width must be great enough to stand the pull of the load and be narrower than the pulley face. For pulleys of the above-mentioned dimensions the arc of contact is ample to minimize slipping. Leather should prove adaptable for a punch press drive and will be the material considered in these calculations.

A simple formula that is usable for most belt problems is as follows: $W = (33{,}000 \times \text{hp.}) \div (P \times V)$, where hp. = horsepower; V = belt velocity; P = effective pull per inch of width. For single belts, use P as 35 lb. per inch in width, while for double belts 70 lb. may be allowed. $V = (\pi \times d \times s) \div 12$ or $(3.1416 \times 6 \times 1{,}750) \div 12 = 2{,}748.9$ or, for practical calculations, 2,750 f.p.m. Substituting this value in the formula for width we have: $W = (33{,}000 \times 15) \div (70 \times 2{,}750) = 2.57$ in. Instead of using a 2½-in. double belt I would use the next size larger which would be a 3-in. double belt.

Schenectady, N. Y. JOHN B. RAKOSKE.

* * * *

Where Should I Use This Kind of Wire?—Most manufacturers of wire for use in house wiring and in industrial plants make three kinds of wire: a Code wire, an intermediate grade and a 30 per cent rubber compound grade. I should like to learn from other readers whether they use all three grades around their plants and if so, the basis on which they decide the grade that shall be used for a certain application. Do you find any of these grades unsuited for industrial plant use? I shall appreciate any information that you can give me regarding the proper application of these three grades of wire.

Newark, N. J. B. S.

In the October issue of INDUSTRIAL ENGINEER there is given an answer to a question asked by B. S., regarding different kinds of insulation of wire and the conditions under which each should be used. I do not agree with some of the statements in this answer to the question asked by B. S.

Code wire is not of the highest quality, as would be believed from this answer, but represents wire that will pass the comparatively easy tests required by the Fire Underwriters.

What, in the question and its answer, is referred to as "30 per cent rubber compound grade" would be better designated as 30 per cent Para or Hevea rubber. The rubber compound containing that proportion of the grade of rubber specified is, when properly made, the highest type of rubber insulation.

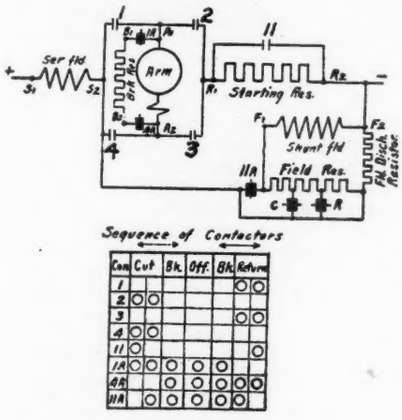
The intermediate type generally contains about 25 per cent of Para or Hevea rubber and has insulating qualities lying between the other two types of rubber insulation.

If you leave the wiring of your plant to a contractor and do not specify what kind of rubber insulation he must have on the wire, you will get Code wire for it is the cheapest that will pass the Underwriters' requirements. If you want the best type of insulation, either because you cannot afford to have shutdowns on account of breakdowns of the wire, or if you have unusually difficult conditions to meet, due to dampness or special manufacturing processes, use the 30 per cent Hevea or Para compound. If you want something better than the Code wire, but do not think that you need the very best insulation, or if you cannot afford to pay the price asked for it, use the intermediate grade of insulation.

I do not mean to insinuate that the code wire is not good. It is good, but the intermediate grade is better, and the 30 per cent Para is best.

Westfield, N. J. G. H. MCKELWAY.

Changing Control to Obtain Lower Motor Speed. — The motor on our reversing planer drive is a 10-hp., Westinghouse, frame 90, type SK, shunt-wound motor having a speed range of 250 to 1,000 r.p.m. We have no spare for this motor and when it fails, it is necessary to substitute a 15-hp., 400/1,600-r.p.m., type SK Westinghouse, shunt-wound motor. The automatic control on the planer drive is arranged as shown in the accompanying diagram. The sequence of operation of the contactors is shown in the table. In this tabulation the number of the contactor is given in the left-hand column, the "Cut" column refers to the cut stroke, the "Return" column refers to the return stroke, and the "Bk." column refers to the dynamic braking applied between reversals. The control is arranged so that a low speed is used on the cutting stroke and a high speed on the return stroke. These speeds are obtained by proper adjustment of the shunt-field rheostat. When using the 400/1,600-r.p.m., 15-hp. motor, the speed of the return stroke can be properly adjusted, but the cutting stroke is too fast. Full field on the motor gives 400 r.p.m., whereas a speed of approximately 300



r.p.m. is desired. Can readers tell me any way that I can obtain this speed on the 15-hp. motor without rewinding it or changing its fields? Is it possible to obtain satisfactory results with resistance in series or in parallel with the armature? If so, how much resistance should be used, or how should I go about determining the correct amount?

Indiana Harbor, Ind. A. R. D.

In answer to the question asked by A. R. D. the speed of a d.c. shunt motor may be reduced by decreasing the voltage impressed on the armature. The three limitations of speed control, when using resistance in series with the armature, are: (1) Widely varying speeds with changing loads. (2) Inability to reduce the speed with light loads. (3) Inability to secure stable low speeds.

It is impossible to state just how much resistance should be put in series with the armature in order to obtain a definite motor speed unless the amount of motor current is definitely known.

For illustration we can consider a 10-hp., 230-volt, d.c. shunt motor, drawing 36 amp. from the line, requiring a constant torque during the cutting stroke on a planer. If the control wiring is arranged as shown in Fig. 1, so that the resistance is in series with the armature on the cutting stroke, the voltage applied to the armature will be reduced by an amount equal to the voltage drop across the resistor. This drop in voltage is equal to the resistance of the resistor times the current flowing through it or 36 × 1.5 = 54 volts. The voltage at the armature terminals is 230 — 54, or 176 volts. The

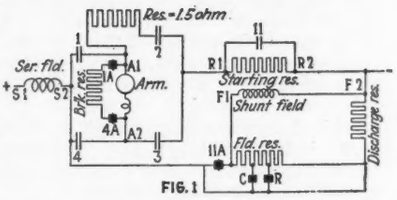


Fig. 1—Reducing the speed of a d.c. shunt-wound motor by inserting resistance in series with the armature.

speed will decrease in direct proportion to this applied voltage. The speed is then equal to (176 ÷ 230) × 400 = 306 r.p.m. If the armature current is only 25 amp., then the voltage drop is 25 × 1.5 or 37 volts approximately. The voltage at the armature terminals is 230 — 37, or 193 volts. The motor speed now equals (193 ÷ 230) × 400 or 335 r.p.m.

In the second case, an armature shunt could be used across the armature as shown in Fig. 2, but this procedure is not recommended by the writer for continuous duty as the current losses in the resistors would be prohibitive. If the shunt resistance method is used, it would be necessary to put a back contact on No. 3 switch and change the brake resistance, because as the shunt resistance is in parallel with it while on the braking point, the resistance path around the armature would be decreased and thus cause a stop which would be much quicker than ordinary. It is not very safe to have this braking current more than 300 per cent of the full-load current. By using the armature shunt, it is possible to reduce the motor speed at all loads, and with light loads a considerable speed reduction results. When the armature shunt is used, it is necessary to put a series resistor between R1 and No. 2 reverse switch, which resistor will be "in" on the cutting stroke.

The speed of the motor, when it is connected as shown in Fig. 2, can be calculated as follows: Armature current = I = 36 amp.; armature volts = E_a = 176 volts; current through shunt = $E_a \div 17.6$ = 10 amp. The drop across the series resistor = $1.17 (I + (E_a \div 17.6)) = 54$ volts. Now, $E_a = 230 - 54 = 176$ volts. Current through the series resistor equals 36 + 10 = 46 amp. Then, speed equals (176 ÷ 230) × 400 = 306 r.p.m.

If A. R. D. desires more information concerning resistance shunts, I would recommend a book entitled "Principles of Electric Motors and Control" by

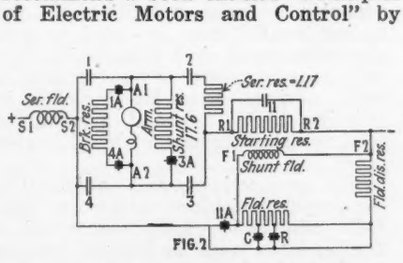


Fig. 2—In this instance the speed of a d.c. shunt-wound motor is reduced by connecting resistance across the armature.

Gordon Fox, published by the McGraw-Hill Book Co.

Foreman, Electric Dept., Carnegie Steel Co., Mingo Junction, Ohio. E. E. STEAD.

* * * *

What Causes Heating of This Cable Box? —There are six 1,000,000-circ. mil cables connected in parallel per phase on the cable run between our 2,000-kw. 3,000-amp., 480-volt turbo-generator and the oil switch. These cables are grouped in six conduits, each of which holds one cable from each phase, or a total of three cables. The conduits terminate in the bottom of a sheet-iron distribution box. In this box the cables are regrouped so that all of the cables from one phase go out of the left-hand side of the top of the box; all the cables for another phase go out through the center of the top of the box; and the six cables for the remaining phase go out through the right-hand side of the top of the box. With this arrangement the entire top half of the sheet-iron distribution box heats up. What causes this heating and how may it be overcome? Should I make the box of fiber instead of sheet iron?

Bellingham, Wash. E. M. D.

In answer to E. M. D.'s problem, the heating is caused by induction. The cables for any circuit, when run in conduit or where a magnetic ring may be formed, should be run as close together as possible. When each phase wire or cable is run in a separate conduit or out of a metal box at any distance apart from the other wires, both the conduit box and the cable will heat. Replacing the metal box with one made of fiber will eliminate the heating of the box, but will not eliminate the heating of the cables. The carrying capacity of the cables is reduced by running them in the manner that E. M. D. has employed.

Electrical Engineer, Provincial Paper Mills, Ltd., Port Arthur, Ont., Can. H. E. STAFFORD.

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If E.M.D. had taken his cables out of the box grouped in the same manner as they entered the box, there would have been no heating because cables from each phase would have passed through the same hole. This heating is not serious on cables or wires carrying a small current, but when larger currents flow this heating effect is more pronounced. The heating is caused by eddy currents induced in the top of the metal box. E.M.D. has no doubt observed that practically all alternating-current magnets are wound on spools, made of either brass or steel, and that the spool has a small slit through its entire length. The object of this slit is to prevent the flow of eddy currents through the metal.

The heating encountered by E.M.D. may be eliminated by sawing a slit from each hole to the adjacent one in the top of the box. This would be the same as regrouping the cables, so that the effect would be the same as though all the cables were carried through the same hole. It probably would not be necessary to saw the slits so that they connected one hole to the other, for a slit cut a short distance on each side of the hole would break up the path for the eddy currents to such an extent that they would be dissipated by the resistance of the additional metal through which the eddy currents would have to flow in order to complete their path.

As the wires are already installed

and in operation, the obvious thing to do would be to saw a slit from the front end of the box towards each hole in the top of the box. This would put a slit clear through one side of the top of the box, which would, of course, open any short-circuited path around the conductors as they pass through the top of the box.

If this work is done while the current is on, some provision should be made to catch the iron dust from the saw as it might cause the switches or other devices to arc across, probably doing damage or injuring someone.

Birmingham, Ala. GRADY H. EMERSON.

* * * *

In a recent issue of INDUSTRIAL ENGINEER, E.M.D. asks what causes heating of a cable box. There is little doubt that this is from eddy currents in the iron of the box between the conductors leaving the box. Temporary relief can be obtained by cutting away the iron between the openings through which the cables pass.

With heavy alternating currents, iron boxes frequently heat. Good practice in this case is to substitute copper or brass in the construction of the box. Transite or asbestos lumber may be substituted where there is no moisture.

Osborn, Ohio. T. H. ARNOLD.

* * * *

Charging Storage Batteries — Will some reader of these columns please inform me how, if possible, I can make up a unit to charge small storage batteries from a 220-volt, direct-current power supply? The storage batteries range from 1 cell (2 volts) to 6 cells (12 volts) in potential and up to 240 amp.-hr. in capacity. Can I charge these batteries from a lamp bank? If so, how many and what size of lamps should I use, and how should they be connected? Any other information that readers can give me along this line will be greatly appreciated.

Chicago, Ill. W. A. B.

The type of charging set for W.A.B. to install will depend on the amount of charging that he has to do. If considerable charging is to be done, a motor-generator set will result in the lowest annual net cost, but in the event that batteries are to be charged only occasionally, the lamp bank type of charging will prove to be the most profitable investment.

When 220-volt lamps are used, the current required by a 32-cp. carbon lamp is 0.5 amp. and a 100-watt lamp requires 0.4 amp. For battery charging work, a 32-cp. carbon lamp is preferable to many types of lamps which are more efficient.

The charging rate of small batteries is about 2 amp. and the rate for the larger ones is 12 amp. After knowing the maximum number of amperes that will be demanded from the lamp bank, enough lamps should be connected in parallel to furnish the required number of amperes during the initial charging period. The current supplied to the batteries can be regulated, when necessary, by cutting some of the lamps out of the circuit.

There is a type of battery charging set on the market, which limits the amount of current supplied to the battery by inserting a carbon compression disk resistance in the line that supplies current to the battery. The amount of current supplied to the charging circuit is regulated by turning a screw that compresses the carbon disks. It has a range of 1 to 30 amp. and is mounted on a stand with a switch ammeter and protecting fuses.

This device for the charging of batteries is inexpensive, besides embodying the advantages of being compact, easily controlled, and quickly adjusted.

Chief City Electrician, Woodward, Okla. H. J. ACHEE.

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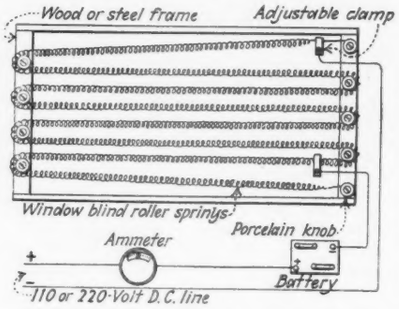
In answer to W.A.B's. question, I wish to submit my ideas on charging storage batteries from direct current power lines. Where central station power must be used, the battery can



Roller curtain springs arranged to limit the flow of current in a battery charging circuit.

be charged cheaper in a regular battery service station, due to the power lost in the resistance bank, necessary to limit the current and voltage to the rating of the battery, when charging from high-voltage lines.

As the resistance is in series with the battery, the battery current must flow through it. Considering a 6-volt battery on charge at a 10 amp. rate from a 220-volt line, the voltage across the battery will be 7½ or 8 volts. The voltage drop across the resistance will be, 220—8=212 volts. Ten amperes flowing in the resistance results in a watts loss of 10×212=2,120 watts, while the battery will require only 8×10=80 watts.

A 100-amp.-hr. battery fully discharged would have to be charged for at least 12 hr. to charge it, with a loss of 2,120×12=25,440 watthours or 25.2 kw.-hr. in the resistance. Power as low as 4 cents per kw.-hr. runs the wasted energy cost alone to a figure above $1.00, while a service station will charge a battery in 8 hours for 50 or 75 cents.

Where plant-generated energy is available in large quantities, the following method may be used to good advantage on all sizes of batteries. The resistance consists of a number of roller springs connected together by twisting their ends and mounted on solid porcelain knobs on a wood or steel frame.

The connections and adjustments for proper resistance values are made with adjustable clamps connected to flexible leads from the line and battery, as shown in the accompanying illustration.

The frame should be mounted in a horizontal position so the heat from the springs will go upward without going over the balance of the coils, as would be the case if the frame were mounted in a vertical position as in the figure. The springs should be stretched so that turns are at the very least $\frac{1}{16}$ in. apart.

I have found that 8 springs in series will give a wide range of control and will pass 10 amp. from a 220-volt power supply. The springs will lose their temper and stretch if subjected to much over 10 amp. unless very good ventilation is provided.

Chicago, Ill. CARL G. HOWARD.

* * * *

W.A.B. can make up a unit for charging storage batteries by using a lamp bank, or the equivalent of a lamp bank with resistance tubes mounted in standard lamp sockets. It would be much better, however, if W.A.B. were to install a motor-generator set for this purpose because it would be much more economical, as the following calculations show:

A 240 amp.-hr. capacity cell has a normal 8-hr. discharge rate of 30 amp., and should be charged at the rate of 30 amp. for about 10 hr. With a lamp-bank charging outfit the current drawn from the 220-volt line would be 30 amp. Therefore, the energy consumed in charging one to six cells would be 220x30x10=66,000 watt-hr. or 66 kw.-hr. At an assumed cost of 7 cents per kw.-hr. the cost of the charge would be $4.62.

If a motor-generator set is used, the generator should have a maximum voltage rating of 16 volts; hence at 30 amp. output its capacity would be 16x30=480 watts of approximately 0.5 kw. A 1-hp. motor, drawing about 5 amp. at 220 volts, would be large enough to drive the generator. It follows from this that the cost of charging with such a set would be 5x220x10x0.07=$0.77.

If it is assumed that batteries are to be charged on a commercial basis, 10 hours per day for 300 days per year, and if we set down $10 and $100 per year as representing reasonable values of fixed charges for the lamp bank and motor-generator equipments, respectively, we find that the cost of charging as assumed is as follows:

For the lamp bank equipment:

Cost of power, 300×4.62	=$1,386 per yr.
Fixed charges	= 10 per yr.
Total	=$1,396 per yr.

For the motor generator equipment:

Cost of power, 300×0.77	= $231 per yr.
Fixed charges	= 100 per yr.
Total	= $331 per yr.

Saving in favor of the m.-g. set = $1,065.00 per year.

This result would have to be modified if the assumptions made do not fit the case under consideration. For a lesser amount of charging per year the saving would be less, while for a larger amount the saving would increase. But if the charging is to be done on a commercial scale, it is safe to say that the motor-generator set is more economical.

The lamp bank equipment can be made up of 60 to 70 100-watt, 110-volt lamps, connected in groups of two in series, in

series with the battery. Each group of two lamps can be separately connected to the circuit by means of a small, single-pole switch. This would give a current range from about 1 to 35 amp. All the parts for this equipment can be bought at any electric supply store.

Resistance tubes mounted in standard Edison lamp sockets can be bought through dealers or directly from the Ward Leonard Co. About 30 to 35 tubes rated at 250 ohms, 200 watts, 220 volts, 0.89 amperes each would be suitable for this purpose, and they are cheaper than the lamps mentioned above.

The motor-generator equipment should consist of a 1-hp., 220-volt shunt motor with starter; a 0.5-kw., 16-volt generator which should be arranged for separate excitation from the 220-volt line; a field rheostat; a series rheostat of about ½-ohm total resistance, 30-amp. capacity; a d.c. reverse-current relay; and two fused line switches, one for the 220-volt line and the other for the 16-volt line.

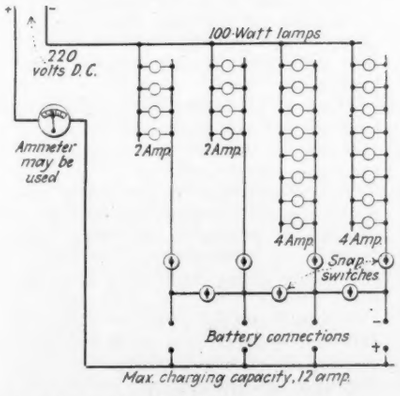
The series rheostat is to go between the generator and the battery and should have at least six steps for adjusting the voltage of the charging circuit. The reverse current relay protects the battery and the generator in case the 220-volt power fails. The motor-generator equipment can be bought from manufacturers agents in Chicago. For addresses see the E.M.F. Year Book, or consult your electrical dealer.

Newark, N. J. H. H. METZENHEIM.

* * * *

W.A.B. can charge storage batteries from a 220-volt d.c. circuit by using a lamp bank to regulate the flow of current to the batteries.

The accompanying wiring diagram shows how a series-parallel arrangement of the lamp in a lamp bank can be adjusted so as to furnish the desired amount of current. Should the starting current be more or less than the desired amount, the proper number of receptacles can be cut in or out of the circuit as required. The fact that a 100-watt lamp allows approximately 0.5 amp. to pass through it, when connected to a 220-volt line, determines the number of lamps that will be needed, which in this case is 20.



Battery charging set designed for use with a 220-volt d.c. service line.

In place of using lamps, the Ward Leonard enameled EB type of resistors can be used. These resistors are designed for a standard lamp base, and the number of sockets needed will depend on the capacity of the resistances employed. When ordering the resistances, you should specify whether they are to be used on a 110- or 220-volt line.

The average charging rate for batteries, when the current is first switched on, is about 10 amp. After the batteries begin to gas, the charging current should be reduced to approximately 5 amp.

When the specific gravity of the liquid in the battery indicates that the battery is fully charged, the supply current is reduced to 2 amp. and this rate of charging is continued for a period of an hour or so. Hydrometers, which are suitable for testing the specific gravity of the liquid in batteries, can be purchased from automobile accessory dealers.

These hydrometers should be so marked that a man who is inexperienced in the charging of batteries, can easily tell when a battery is or is not fully charged.

A storage battery is considered fully charged, when the specific gravity reading is between 1.27 and 1.29. A voltmeter reading, by the way, does not indicate the amount of current available in a battery, unless a reading is taken when the battery is delivering current at its rated capacity.

If you so desired, the switches that are indicated in the sketch can be eliminated; in this case the flow of current can be regulated by screwing the lamps into or out of their respective receptacles.

In order to determine a positive wire from a negative one, two methods are generally employed. The polarity indicator offers the simplest and most convenient method of picking out the positive wire. The other method takes advantage of the fact that, while a small current is flowing, numerous bubbles will rise from the negative terminal of two wires, when they are immersed in a solution of salt and water. A simple way of limiting the flow of current through these wires is to connect a lamp in series with one wire.

During the charging period, all danger of a fire or an explosion can be avoided by keeping open lights away from the batteries while they are gassing.

Birmingham, Ala. G. H. EMERSON.

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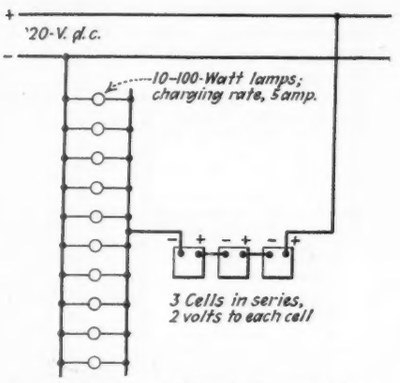
Before proceeding with an explanation to W.A.B's. question, I would suggest that the reader look at the accompanying sketch. Batteries are often charged from a 110- or 220-volt d.c. current supply, by using a lamp bank to regulate the flow of current. From the sketch, it is evident that by adding more lamps to the parallel circuit, more current can be supplied to the battery, and the current supply can be diminished by unscrewing the necessary number of lamps from their receptacles.

The voltage of the lamps should be the same as the voltage of the supply circuit. Although 100- or 150-watt lamps are often used, carbon lamps are



Lamp bank employed to regulate battery charging current.

to be recommended for this work. If a 100-amp.-hr. battery is to be charged use ten 100-watt lamps or seven 150-watt lamps. This arrangement will give a charging rate of 5 amp. When the batteries are nearly charged, the flow of the current can be reduced the necessary amount by unscrewing some of the lamps from their sockets.

In connecting the batteries to the charging wires, only those cells which have the same capacity should be connected in series.

Middlesboro, Ky. C. L. UMBERGER.

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In reply to W.A.B's. question, I would say that a lamp bank consisting of 32-cp. lamps will make a very substantial unit for regulating the flow of current between a 220-volt d.c. line and battery charging terminals. When the line current is 220 volts, 110-volt lamps can be used by connecting them in series-multiple. When 220-volt lamps are used, all the lamps are connected in parallel. One 32-cp. 110-volt lamp will give 1 amp., while one 32-cp., 220-volt lamp will give ¼ amp. Therefore, a multiple of these lamps will give the charging rate required.

As to the number of lamps to be used in charging, of course, one must not exceed the charging rate. Therefore, it would remain for W.A.B. to decide the charging current most suitable for the battery on charge. There are two methods of charging: one is to apply the full rated charging current to the batteries until they are nearly charged. Then the current rate is reduced to one-half to finish off that charge. The other method is to apply one-half or less of the charging rate to the batteries; this will lengthen the charging period, but seems to be easier on the battery than the higher charging rate.

As to connecting the batteries, it is only a matter of connecting the different batteries, positive to negative. As to the ampere-hour capacity of the batteries, the charging period should be recorded at start and finish; then multiplying the charging rate in amperes by the number of hours the battery was on charge, will give the ampere-hours put in the battery. Personally I use the specific gravity and voltage for guidance in charging batteries. Most automobile or other small batteries usually

have the electrolyte of 1.280 to 1.300 specific gravity, with a voltage of 2.6 volts per cell when the cells are fully charged.

Maintenance Inspector, E. J. EVISH.
Kaministiquia Power Co.,
Fort William, Ont., Can.

* * * *

Method of Connecting Generator to Bus.—In the power house of our lumber mills we are planning on installing a 6,000-kw. three-phase, 480-volt, 9,000-amp. turbo-generator. To the bus there are now connected an 800-kw. and a 2,000-kw., 480-volt generator. I would like to know what readers would recommend for connecting the 6,000-kw. generator to the bus. Should cable be used, and if so, how should it be arranged so as to eliminate the inductive effect and its consequent heating due to the heavy current flowing? Would it be better to use busbars and if so, how should they be supported and arranged so as to reduce the induction? Any recommendation that readers can give for the layout of the connection between the generator and bus will be appreciated.
Bellingham, Wash. E. M. D.

Referring to E. M. D.'s inquiry, it would seem that for a machine of this size such a saving in copper and control apparatus could have been made by changing to 2,300 volts as to justify some changes in the driven equipment about the plant.

If the run from the new generator to the switch and bus is not too long and crooked, busbar copper may be used to advantage. A current density of at least 1,000 amp. per sq.in. could be used in which case a 9,000-amp. current would require 9 sq.in. or three ½-in. by 6-in. busbars. These bars could be carried in the usual way without any danger of induction or heating of the busbars.

Should it be necessary to use cable, nine 2,000,000-circ.mil cables will be required per phase. These cables can be fanned out from the machine terminals and secured to the ceiling or wall, the main precaution being to keep all the cables of one phase together so as to avoid induction troubles.

We have a similar installation, although both of our generating units are smaller than the one E. M. D. has reference to, and our units require only two cables per phase instead of nine. Standard, porcelain-bushed cable racks are used and have never shown any indications of heating or trouble.

If, however, it is necessary to run these cables in iron conduit, the same number of cables must be used for each phase. In each conduit must be grouped one A, one B, and one C cable or a multiple of this combination, and all cables should be brought to a common terminal at the far end from the generator. Also, all the conduits should be solidly connected together with heavy ground clamps at both ends of the cables.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.
New Haven, Conn.

* * * *

In answer to the above question by E. M. D., my advice would be to approach the problem with caution and get the best advice available. The writer assisted in the solution of this problem on one occasion and has used a different solution on subsequent problems in order to secure a proper layout of the connections.

The installed cost of the electrical equipment for a unit of this current rating is excessive in proportion to the kilowatt capacity, the switching equipment is cumbersome and of special design, deliveries are slow, and some equipment is none too satisfactory in operation. The unexpected difficulties from induction may form a very appreciable addition to the expense and trouble incident to getting the new unit into operation.

In 1916-17 one of the copper mining companies installed a 6,000-kw., 480-volt, three-phase, 60-cycle, turbo-generator as an addition to a plant having one 2,000-kw. turbo-generator and three 1,250-kw., engine-driven units.

Preliminary designs and cost estimates were made for both copper bar and cable connections from the generator to the switching equipment. The cable arrangement gave the best installation in this case. Eight 2,000,000-circ.mil, v.c., single-conductor cables per phase were used.

This arrangement required 24 runs of 80 ft., totaling 1920 ft. of cable. To avoid induction drop the cables were made up in sets of three, one set for each phase, and each set was given a complete twist in 9 ft. The result resembled an overgrown telephone cable. Large brass castings placed on 3-ft. centers maintained the cables in position and supported the weight. Micanite bushings protected the insulation where the cables passed through the supporting castings. The inductive drop was negligible and the finished appearance was neat and workmanlike in every particular.

Two, three-pole, 5,000-amp., electrically-operated carbon circuit breakers were connected in parallel for the main switch. These were arranged to be operated either singly or together from the switchboard. In synchronizing one breaker was used, the second breaker being closed after the machine was paralleled.

The bus leaving the switches was divided into six parallel sets of bars. A number of additional feeders were added at this time, and the total new copper to reinforce the existing bus system was approximately 19 tons of ¼-in. by 5-in., hard-rolled copper bar.

A short-circuit, which developed on the bus shortly after the new bus was placed in commission, demonstrated the wisdom of wide spacing of the bus and secure anchorage of the bars. An 8-in. to 10-in. clearance should be maintained between uninsulated conducting parts, or suitable barriers should be installed.

The copper should be figured very conservatively; the current density should not exceed 500 amp. per sq.in. Where more than five ¼-in. by 5-in. bars are required, the bus should be split into two or more parallel runs. Great care should be exercised in the make-up of all joints and taps in the bars to prevent them from becoming overheated and causing trouble.

All iron should be eliminated so far as possible from the bus structure and adjacent parts. Brass or bronze should be used for bolts, washers, bus clamps, bus supports and framework. In the above installation, extra-heavy, 1¼-in. brass pipe was used for the supporting frame. Even with this precaution, trouble developed from induced currents circulating in the framework and heating the pipe. Many of the joints had to be insulated before this trouble was remedied. Building steel and reinforcing in the concrete were affected. The expense incident to remedying these unexpected troubles was quite large and became quite serious before the remedy was satisfactorily worked out and applied.

The final effect was an entirely satisfactory solution of the problem in that the engineering difficulties were overcome. From the economic aspect, however, the cost of wiring, control, and metering equipment formed an undue percentage of the total installation cost.

As the problem is given, there appears to be a very considerable increase in generating equipment which presupposes an increase in motor equipment. Probably the most satisfactory arrangement would be the installation of a higher voltage distribution system with stepdown transformers, and transformer connections to the existing system.

Osborn, Ohio. T. H. ARNOLD.

* * * *

Trouble with Storage Battery Charging Generator—We are having considerable trouble due to the reversal of polarity on a 50-kw., 120-volt, interpole generator which is used to charge storage batteries on vehicles. The machines were tested for grounds by means of a Megger and a heavy leakage to ground through the acid-soaked benches in the battery charging department was discovered. Having remedied this, the generator was started and immediately the voltmeter read backwards with no load on the machine. We checked the leads from the machine, but they were of such size and so taped together that it would be impossible to reverse them by mistake. We tried to re-excite the field, but could not; so the leads were reconnected so as to reverse them at the generator and not disturb anything at the switchboard. The generator worked satisfactorily for about three days, when the polarity again reversed itself. We reversed the generator leads to their original position and since then the machine has been operating satisfactorily. I do not know what caused this reversal of polarity and should like to have readers give me their suggestions.
Sacramento, Calif. J. T.

It seems likely that the generator which J. T. is puzzled over, has received enough return voltage to change the polarity of the field.

This could also be caused by other apparatus in the line that would discharge through the field in the event that the circuit from the generator was broken.

There is no reason for not being able to re-excite the fields, as only enough voltage is needed to overcome the residual magnetism.

The re-exciting of the fields can be accomplished by applying current from an outside source to the field (shunt) coils, or by insulating the brushes from the commutator and then closing the main switch.

I would advise J. T. to look around for poor connections, or to consider the possibility of the batteries discharging through the generator.

Chief Electrician, E. J. MORRISSEY.
Western United Gas & Elec. Co.,
Aurora, Ill.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Method of Cleaning Stranded Wire Before Applying Solder

STRANDED wire may be very easily cleaned in preparation for soldering, if one will first strip off the bulk of the rubber insulation and then rub the exposed wire strands lengthwise with a piece of file card.

The short stiff wire bristles of the card will dig down between the rounds of the strands, cleaning and at the same time slightly roughening the surface of the wire.

To one who has wasted time and temper, trying to clean between the strands of wire with the point of a knife, this method will be found to be a big improvement over the customary procedure.

Providence, R. I. JAMES P. MARSHALL.

Placing Ground Wire in Conduit Insures Protection

IF THERE is any wire in an installation which needs mechanical protection, it is the ground wire. When other wires become broken or disconnected through mechanical injury, the fact immediately becomes evident through the failure of the equipment depending upon the wire, but if the ground wire becomes inoperative, the fact is generally not disclosed until too late. Furthermore, ground wires, because of the location in which they are placed, and especially in the vicinity of the water pipe connection, are particularly subject to mechanical injury.

The National Electrical Code, section 905 D, requires that all ground wires shall be protected from mechanical injury. About the only feasible way to protect the ground wire adequately is to put it in conduit, not part of the way, but all of the way, and unless it is made up to the water pipe with conduit types of ground fittings the conduit should terminate in an iron or wooden box, enclosing the ground clamp and connection.

The methods of grounding shown in the accompanying diagrams are very satisfactory under the present Code requirements. It will be observed that a common conductor is employed for grounding both the conduit and the service wires. This conductor consists of a copper wire in multiple with the protective conduit. Placing the protective conduit in multiple with the copper wire decreases the resistance of the circuit to about one-third of its previous value and about doubles the carrying capacity. There are many other obvious advantages.

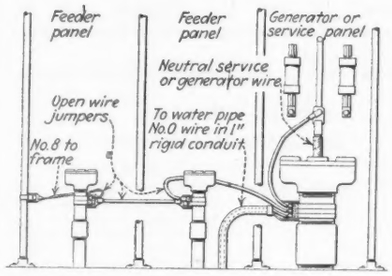

Feeder panel
Feeder panel
Generator or service panel
Neutral service or generator wire
Open wire jumpers
No.8 to frame
To water pipe No.0 wire in 1" rigid conduit

Fig. 1—This method of making a connection to the ground wire is particularly adaptable around a generator or service panel.

The National Electrical Code, Section 905E, reads as follows:

"Where a secondary system is grounded at the service, the equipment, conduit, armored cable, metal raceway and the like may, with the permission of the inspection department, be connected to the circuit grounding conductor, but otherwise shall have a separate grounding conductor of their own."

When the local inspection department objects to the use of a common conductor, the method shown may very readily be modified to provide for two independent conductors.

When two independent conductors are used the question is sometimes raised at to whether or not the Code permits the protective conduit to be used as the grounding conductor for the service entrance conduit. Such use of the protective conduit has been specially approved by the Underwriters' Laboratories.

Manager, Groundulet Co. Newark, N. J. S. W. BORDEN.

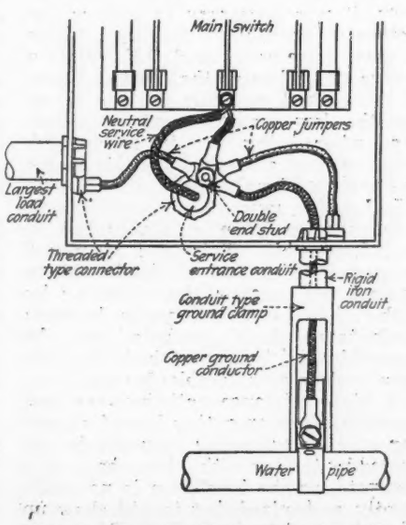


Fig. 2—Showing how the ground wire is protected and one method of connecting conduits to ground.

The bushings used on the end of the conduits are made of galvanized malleable iron. These bushings are designed to accommodate a bronze soldering lug which makes a direct contact with the conduit and at the same time locks the bushing in place.

Testing Insulation Resistance of Electrical Equipment

DIRECT-READING, insulation-resistance-measuring devices have many uses around an industrial plant. For example, they will show at a glance the condition of the insulation in light or power wiring, either at the time of construction or after the plant is in operation. The ordinary magneto will show short-circuits and direct grounds, but it does not show swinging or high-resistance grounds and, therefore, is not an entirely reliable instrument.

In testing motors, a device that will measure the insulation resistance is a practical necessity. Very often, while a motor is at rest a ground cannot be found by the ordinary magneto or bank of lamps, for the reason that the coils assume their natural positions, while when running the internal stresses due to magnetic induction and centrifugal force will distort the coils and chafe the insulation, causing a so-called swinging ground. The writer has come across several cases of this kind which have been readily found with a Megger.

It has been the practice of the repair department in the plant with which the writer is connected, to test all coils as they are inserted in a motor during a rewinding job. This test shows the condition of the insulation not only between the coils and the core, but also between the layers of various coils.

In locating faults in compensators and controllers, the insulation-resistance method is the only means of locating a high-resistance path through mica, wood or fiber. Where water or metallic dust has caused a path between contacts, a carbon path of high resistance is usually formed in the insulation. It is difficult to locate this path by the ordinary magneto or lamp bank, but with a suitable megohmmeter the resistance can easily be measured.

According to the Standardization Rules of the A.I.E.E., the insulation

resistance of a machine at its operating temperature shall be not less than that given by the formula:

Insulation resistance in megohms = voltage of terminals ÷ (rating in kva. + 1,000)

This rule should be adhered to as it is really low, and might be also considered arbitrary, especially on machines of high rating. For the sake of comparison, the accompanying table shows the safe limit as required by the above rule, and what I consider the safe limit from my experience with all types of equipment over a considerable number of years.

Although the A.I.E.E. formula may give an insulation resistance that will be ample under various conditions, from my point of view I feel that it is not infallible. For instance, when it is applied to a 75-hp. and a 200-kva. motor, both operating at 550 volts, the results are 520,833 ohms in the first case and 458,333 ohms in the latter.

In practice, I do not consider it safe to attempt to place in service a motor that shows a reading below 750,000 ohms when the impressed voltage is 550 volts.

Not long ago, at our plant, a motor gave out and two coils had to be replaced. In order to do this, the top sides of ten coils had to be lifted and replaced. The windings were then dipped and baked for 48 hr. While still hot, a Megger test was taken and a reading of 600,000 ohms was recorded. Although this reading was not so high as expected, the motor was put back in service and lasted three weeks, when two coils in each of two phases broke down to ground. The motor was in a perfectly dry location and operated 20 hr. per day in two shifts of 10 hr. each.

In winding motors with a complete set of new coils, I try to get a reading of at least 10 megohms, cold test, for motors with open slots and from 100 megohms to infinity, cold test, for motors with partially-closed slots.

In testing power wiring in conduit at our plant, nothing short of infinity on a 100 megohm Megger is accepted, with the wires disconnected at both ends, and four megohms when connected through service switches, compensators and motors. This is, of course, for a new installation operating at 550 volts.

Compensators and a.c. controllers must show on test not less than 500,000 ohms; otherwise they are overhauled and re-insulated. The same, or a higher, reading is required on all d.c. control apparatus, for both 220 and 550 volts. Commutators, armatures and field coils are not considered in good condition when they give a reading of less than 750,000 ohms.

Following are the results of some tests made recently:

Test No. 1—75-hp. motor, 1,800 r.p.m., three phase, 550 volts, direct-connected to a centrifugal pump. Reading when installed, 50 megohms: reading after two years' operation in a damp place, hot 9 megohms, cold 10 megohms.

Test No. 2—35-hp. motor, 1,200 r.p.m., three phase, 550 volts, rewound. Cold test of each phase, open: to ground, 8 megohms. Cold test when star-connected, 10 megohms. This motor had open slots and form-wound coils, varnished but not baked after winding.

Test No. 3—10-hp., 1,800-r.p.m., three-phase, 550-volt motor with partially-closed slots, 55 turns per slot. Test of each coil as inserted, infinity. Test of completed winding after wedges were inserted, infinity. Test, both hot and cold after being dipped and baked, infinity.

Test No. 4—50-hp., 1,200-r.p.m., three-phase, 550-volt motor. This motor had 18 defective coils removed and replaced with new ones. This necessitated lifting 10 extra coil sides which were afterward replaced. After being repaired, the motor was varnished and baked. When taken from the oven and allowed to cool, the Megger gave a reading of four megohms. After standing in the shop for three months, a reading of 800,000 ohms was registered, due to collection of moisture. An ordinary magneto gave no signal.

Safe Values of Insulation Resistance

Machine Rating		A.I.E.E. Standard,	Writer's Standard,
Volts	Kva.	Megohms	Megohms
110	20	0.10784	0.25
220	20	0.21568	0.5
440	50	0.419	0.75
550	100	0.5	1.0
1,100	100	1.0	2.0
2,200	100	2.0	5.0
11,000	500	7.33333	20.0
22,000	1,000	11.0	Infinity

Test No. 5—Four high-speed, 550-volt motors, ranging from 5 to 25 hp. were submerged, due to a blocked sewer. The motors were taken out of service immediately and placed in an electric oven. After being in the oven from 5 p.m. to 8 a.m. the following morning, they were taken out and tested. Three of them gave hot readings of 900,000 ohms, 1 megohm and 1.2 megohms respectively, while the fourth gave a reading of 250,000 ohms. As part of the mill was down, it was necessary to replace the motors as quickly as possible. Three of them were considered O.K., while a chance was taken on the fourth. Three of them stood up while the one showing the low reading went out three days after being put in service. A magneto was also used on this motor and gave no signal.

In locating swinging grounds I have found the insulation-resistance test to be indispensible. This type of ground is caused by chafing of the insulation against the core or slot sides, or by high-resistance carbon paths between conductors. Such grounds can be located by the "smoke method," but this usually does considerable damage.

A high-resistance path between two contacts of an operating bar of a compensator or controller may not be revealed by testing with a lamp bank or a magneto, as the insulation is not sufficiently carbonized, but it will show up when full voltage is applied. Of course, where a fuse is blown and no trouble is found in the motor, a short-circuit is assured, but if a magneto or lamp bank shows no short-circuit, the trouble is mystifying to say the least. I have had several cases of this kind where the needle of the Megger would swing from zero to infinity in successive oscillations, on account of the path being broken and closed by the movement of minute particles of carbon during the passage of the current. This may sound theoretical, but the fact remains that this is what actually happens.

Electrical Engineer, H. E. STAFFORD.
Provincial Paper Mills, Ltd.
Port Arthur, Ont., Can.

Types of Signal Systems Used Around a Cement Plant

INDUSTRIAL signals may generally be divided into two principal classes: audible and visible. The bell and the horn are the main representatives of the former class; the light and the semaphore of the latter.

Every one of these signals has its own particular field, and, if intelligently applied, will make for greater safety and production.

In cement plants, audible signals find a much wider application than visible signals; to anyone familiar with the operation of cement plants the reason is obvious—mill operators and others do not stay in one place all the time, but are often in a position where they would not notice the flash of a light, yet the sound of a horn or a bell would easily attract their attention.

In choosing an audible signal, however, care must be taken in order to have the sound of the signal as different as possible from the noise of the running machinery. Where Kominuters, tube mills, griffin mills or almost any other type of grinding machinery is running, the sound of a bell or gong is very difficult to distinguish, while a horn will be easily heard.

In storage places, in stockhouses and along conveyors, a small clear-toned bell, which is much cheaper than a horn, will generally be quite satisfactory.

Visible signals find their main field of application outside of buildings, around quarries or in places where the attendant or operator has to stay in one place all the time, such as at the mixing scales, packing machines, where gypsum is added to the clinker, where men are tapping cement in stockhouse tunnels, and the like. In all these places the light, which is inexpensive, is quite satisfactory.

In the case of quarries where blasting operations are carried on intermittently and at no particular set time, both visible and audible signals should be used. A warning should be given not only to plant employees but to anyone who might approach the quarry, especially if it is situated near roads where anyone might be traveling while blasting is going on. In such cases, a system of signalling such as outlined below may be used to advantage.

A stone-proof shelter should, of course, be provided where all quarry employees will be safe.

The steam shovel attendant should give the first signal, long enough before the blast, for anyone near the quarry to take shelter. From this shelter, it should be possible to operate all the signals, or to signal to some other employee whose duty it is to operate them.

For the safety of the employees in other departments of the mill, horns should be placed just outside of all doors which are within reach of flying stones, where men might happen to walk out at the time of blasting.

If railroad tracks are near the quarry, such as tracks for bringing in clay, shale, gypsum or coal, or for shipping cement or rock, semaphores should be placed in such positions that the train crews will be sure to notice them and know that blasting is going on.

A large bell operated with a rope, such as is generally used on locomotives, also makes a very effective signal which can be heard for a long distance.

With such a system of signals operated from the shelter, there should be very little chance of accidents from flying stones, provided ample time is given everyone to get safely away before a blast. A push button switch with the circuit normally opened, connected into a 110-volt lighting circuit, gives a safe and reliable means of signaling.

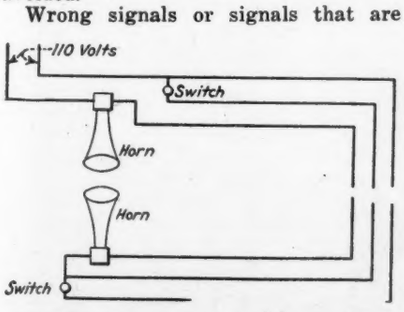
In the case of McCaslin or other kinds of bucket conveyors which dump into a storage and also tap out at the bottom of storage, two horns connected in series, one placed above and one below the storage with a push button switch near each horn, as shown in the accompanying sketch, make a very reliable system of signaling. With the connections shown in the sketch, the attendant either above or below will know something is wrong if his horn does not blow when he presses the button.

No system of signaling, however, will be of much practical use unless certain employees are assigned to do the signaling and are held responsible for it. Every foreman should be absolutely familiar with the system of signaling employed in his department, and he should be held primarily responsible. Also, the foreman should see that all employees under his direction understand the signals used and that nobody but the one assigned to that duty gives the signals. The assigning of one man to give the signals is very important and, in the case of conveyors or other machinery where generally the man starting the motor cannot see that all the machinery thus set in motion is clear, it is absolutely necessary in order that serious accidents be avoided.

Wrong signals or signals that are misunderstood are worse than no signals at all, for men will depend on them and this false sense of security will often lead to serious if not fatal accidents.

Industrial signals should be judiciously and intelligently applied, should be understood by all, and foremen should strictly enforce the use of the signals besides seeing to it that the signals are heeded and obeyed to the letter.

J. H. GALLANT.
Chief Electrician,
Canada Cement Co., Ltd.,
Belleville, Ont., Can.



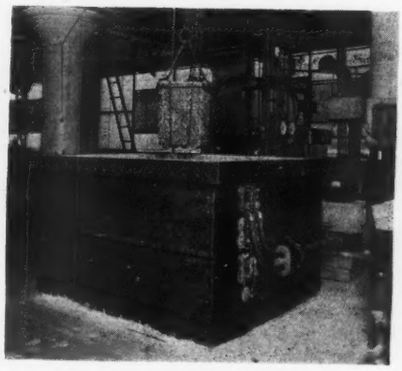
This signal system is so connected that when the horn near the operator fails to work the other horn does not blow.

The operator is thus warned of trouble in the signal system.

Use of Electric Furnace for Annealing Relay Parts

THE relay, upon which the railway signal system depends for its operation, is composed of parts made up of soft Norway iron. After the various machining operations, this iron retains a certain amount of magnetism that can be removed only by careful heat-treatment.

The Union Switch and Signal Co., Swissvale, Pa., manufacturers of railway signaling devices, uses a pit-type electric furnace for this heat-treating process, for the reason that accurate temperature control and uniformity of heating are essential.



This shows the pit type electric furnace being charged with iron relay parts which are to be annealed.

In this Westinghouse electric furnace, the heating chamber is 34 in. by 44 in. and 36 in. deep. The heating elements, of 75 kilowatts rating, are arranged in a double bank on all four sides and on the bottom. The bottom elements are covered by the cast floor plates. The 13-in. wall consists of a firebrick lining and insulating brick. An overhead chain hoist with a short transfer rail is used to handle the furnace cover and the charge, thus greatly facilitating their movement.

The charge is placed in Nichrome pots, and the covers sealed to prevent oxidation during the comparatively long heating process. From one to four of these boxes are placed in the furnace, the cover put on, and the power then applied.

The time required to reach the required temperature is about 5 hr. The work is allowed to soak at this temperature for 1½ to 2½ hr., depending upon the size of the charge.

The charge is allowed to cool in the furnace until the boxes can be handled. This operation usually requires about 20 hr.

A test of one run, in which four boxes containing a charge of 2,880 lb. were heat-treated, showed that 473.5 kw.-hr. were consumed. At 1.4 cents per kw.-hr., the total cost was $6.63 or $0.0023 per lb. of charge. This is a proven consumption of 0.164 kw.-hr., per net pound of charge put into the furnace.

The use of electric heat for this heat-treatment is efficient and economical in that it saves labor and time, eliminates continual watching, and results in an extremely low percentage of rejections under rigid specifications. The operating cycle has been so arranged that the furnace is charged during the morning period.

Before the day is over the charge will have reached the necessary maximum temperature, and will have soaked the proper length of time. The cooling period then starts and is completed some time the next day.

Simple Relay for Lighting Lamp When Telephone Rings

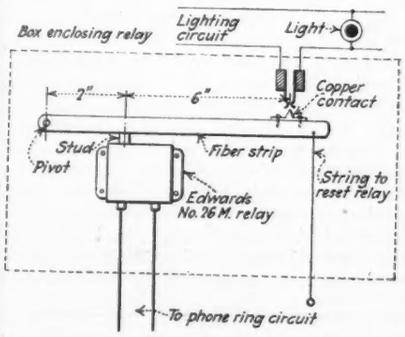
RECENTLY, we installed a telephone in a quarry but, there seldom was anyone near enough to hear the bell. It was, therefore, necessary to provide some sort of signal that would be visible. The accompanying sketch shows how a lamp was made to light whenever the bell rang.

The reset stud on an Edwards No. 26 M. relay was arranged to operate a fiber strip that was pivoted at one end. This stud has a travel of about ¾ in.; so the relay was placed in such a position that the travel of the stud was multiplied to ⅜ in. at the copper contact which is attached to the fiber arm, as shown in the accompanying sketch.

Whoever answers the telephone pulls the reset string, breaking the contact to the lamp, and leaving the relay ready for the next call. It is evident from the sketch that there is no danger of the 110-volt circuit becoming grounded or crossed with the wires of the telephone circuit.

This relay has operated very successfully since its installation.

C. A. PETERSON.
Chief Electrician,
U. S. Gypsum Co.,
Alabaster, Mich.



When the telephone bell rings the relay is energized, causing the lever arm to close the 110-volt circuit and light the lamp.

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Use of Individually-Driven Rolls on Billet Conveyor

WHEN building a conveyor that was designed to carry steel billets from a furnace to a machine which was placed at a 90-deg. angle from the furnace door, a difficult mechanical problem was encountered in driving the eight rolls that were necessary on the conveyor. To convey the billet around the curve each roll had to be placed at a slight angle from the preceding roll. The first roll conveys the billet straight out from the furnace and each succeeding roll was placed at approximately a 12 6/7-deg. angle from the preceding roll. Thus, each roll turns the billet an equal amount until it has made a quarter turn.

If a mechanical group drive had been used, it would have been necessary to have connected a 7½-hp. motor to a mainshaft through a set of spur gears and then install short jackshafts (seven in all) between each set of rolls, with especially-designed bevel or spiral gears driving to each roll and each roll in turn driving the succeeding roll. In addition to the large number of expensive gears, which would have been required, it would also be necessary to use two bearings between each set of rolls for each of the jackshafts.

The accompanying illustration shows how the drive was eventually worked out. A 1-hp., 850-r.p.m. Reliance squirrel-cage motor was connected to each of the eight rolls, driving through a pinion and internal spur gear because of space limitations. If a straight spur gear had been used, it would have been necessary either to mount the motor above and drive at the top of the gear, or to lower the motor into the floor and drive at the bottom, if the motor were to be kept on the same line as the roll. Therefore, to make a better appearing and more compact drive than would have been possible if the motor had been mounted at one side, it was deemed advisable to use an internal gear. For protection against dust, covers will eventually be put over these internal gears.

All motors are started and stopped simultaneously from a single starting box. The drive is tied together by an electrical circuit with a single control instead of the complicated mechanical drive first throught of, which would have been more expensive to maintain.

One side of the motor feet was machined parallel to the shaft and a pad on the base plate was finished to fit this machined surface. This made it possible to line up the gears accurately and quickly and use a smaller base than would have been possible if the motor had been mounted to one side. A spare motor was purchased as a protection against a possible breakdown.

J. W. COREY.
Reliance Electric & Engineering Co.,
Cleveland, Ohio.

Comment on "Methods of Reducing Friction Losses"

I HAVE just read the article, entitled "Methods of Reducing Friction Losses" published in the October issue of INDUSTRIAL ENGINEER, and it seems to me that this article exaggerates the inferiority of the so-called plain bearings as compared with the so-called anti-friction bearings.

What I refer to especially is on page 461 where the following sentence occurs: "These bearings require greasing a few times a year at the most, instead of daily or at very frequent intervals, as is the case with plain bearings."

Now as this article confines itself principally to lineshaft bearings I am sure that in 999 case out of 1,000, plain lineshaft bearings today are ring-oiled, and this being the case there is absolutely no necessity for either daily or very frequent oiling of bearings of this construction.

If only people would keep their hands off them they will run lovely for a year at a stretch and as a matter of fact we have had them running in our own shops for 19 mos. without giving them any attention whatsoever and without experiencing the slightest trouble. The Jones & Laughlin Steel Co. states in one of its catalogs that it had a whole installation of ring-oiled bearings in a machine shop running from July 1893 to August 1896 without ever giving them the slightest attention whatsoever and upon inspection at the latter date they were found to be in perfect condition.

So please don't hit the good, old plain bearings too hard, because if only given half a show they are exceedingly good and efficient.

H. F. GADE.
Vice-President,
Standard Pressed Steel Co.,
Jenkintown, Pa.

NOTE: The comments and experiences of other readers on this subject will be welcome.—EDITORS.

Eliminating Trouble from Static on Belt-Driven Machines

STATIC from belt drives, particularly if the belt passes near the hair of women employees, or if it is generated in rooms filled with explosive or inflammable vapors, must be removed or prevented. Friction, high speed, dry belts, and dry air, and so on, are all

The eight rolls are driven separately through internal gears by 1-hp. motors.

contributary causes of static electricity. Friction, however, is the principal cause and therefore the first step in preventing static electricity is to eliminate belt slip. Two of the main causes of slippage are belts which are too loose or too small for the service they are giving. Where poor adhesion of the belt to the pulley is the cause of the slip, the difficulty can frequently be overcome by using a belt dressing or by covering the pulley.

Where dry belts are the cause, or a contributing cause, of static, this difficulty may be overcome by keeping the belt "damp," that is, soft and pliable. The best way of doing this is to use a reliable belt dressing which will work into the belt and not only soften the surface but lubricate the fibers of the leather. It is well to be careful, however, and not overdo the treatment, because using too much dressing is likely to cause the belt to slip, which causes friction and again generates static electricity. In some plants operating men use a mixture of 50 per cent glycerin and 50 per cent water on the belt to keep the surface moist. However, a good belt dressing is to be preferred.

If the static electricity is not stopped by either of these methods, it can be removed with a grounded copper wire by "combing" it off the belt by means of a comb of fine copper wires suspended so as to touch or nearly touch the belt, at a point mid-way between the pulleys. When necessary, combs should be placed on both sides of the belt, but there should not be enough pressure to scratch or injure the belt in any way.

The wire leading from the comb should then be grounded to a water pipe or to anything metallic that extends down into the moist earth. Where such ground connections cannot be made to an existing structure it is sometimes necessary to drive a pipe into the ground to make the connection.

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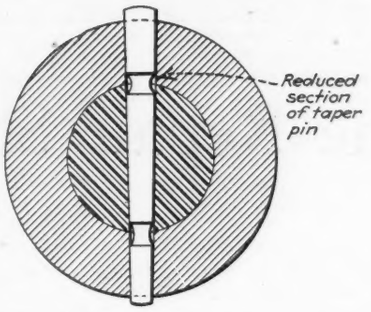
Using Breaking Pins to Protect Drives Against Overloads

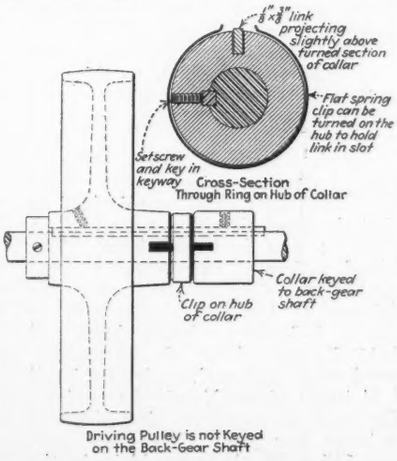
PROTECTION against overloads in mechanical drives which may be stopped suddenly is just as necessary as the fuse in electrical circuits. In many cases on belt drives the belt serves as the safety device in that it will slip or run off the pulley if the machine stops suddenly. However, if the belt tension is high the possibility of slipping is decreased also, the belt will slip off the pulley more slowly, and some part of the machine may break first. For this reason it is often desirable to place a safety link of some kind in the driving mechanism of the machine. These safety links are usually in the form of breaking pins or shear links, which have a cross-section sufficient to drive ordinary loads, but are weaker than any other part of the drive, so that they will break first and protect gear teeth or other more expensive elements of the drive. The following examples show how these links were used in three instances.

On each of a battery of duplex milling machines, a box, containing the trip, feed drive, and reverse gears, is suspended from the saddle at its front end. This box is attached by four long screws with the heads counterbored in the saddle of the tableways. This construction is neat and substantial and when assembled nothing but the line where the faces meet shows that it is a two-piece construction. However, the last member in the feed mechanism is a hardened worm that drives the hardened gear through which the splined table-screw passes. This worm is attached to its shaft with a No. 3 taper pin which serves as a breaking pin and, whenever the work jams, the hard worm on the hard shaft cuts the pin off completely. This shop uses belts of such size and under sufficient tension to make them proof against slipping, which makes the feed or drive stronger than the pin.



Method of installing a breaking pin in a gear drive.

By decreasing the cross-section of this taper pin, which holds a driving gear to its shaft, a safety link is placed in the line of power transmission. This link breaks whenever an overload is thrown on the milling machine. The pin is easily replaced.


⅛"x⅜" link projecting slightly above turned section of collar
Flat spring clip can be turned on the hub to hold link in slot
Setscrew and key in keyway
Cross-Section Through Ring on Hub of Collar
Collar keyed to back-gear shaft
Clip on hub of collar
Driving Pulley is not Keyed on the Back-Gear Shaft

Details of a safety link in a back-geared drive.

When the work jams this link breaks. The link, which is a piece of ¼-in. by ⅜-in. steel, fits into a slot on the loose pulley hub and in a collar keyed to the shaft. A flat spring steel clip fits over a neck which is turned down on the end of the collar and holds the safety link in position, as shown in the sketch. An overload breaks the link and leaves the pulley free to turn on the shaft. The operator keeps a supply of extra links on hand and can replace a broken one by slipping the spring clip around, until the gap between the ends is over the slot.

When the pin is sheared, the table must be removed before the gear box can be taken off to get at the worm and replace the tapered pin. This is a heavy job either with the table stripped or with the fixtures left on and it takes two men about 2 hours to replace a broken taper pin.

The Master Mechanic decided, after a few such experiences, that, while a breaking piece was necessary, it should be located where it was more convenient. The construction was changed so that the breaks now occur at a more accessible gear outside the box, due to the weakening of the No. 3 taper pin which holds this gear to its shaft. Now, all of these milling machines have this one easily accessible spot where the taper pins have a reduced shearing section, as shown in accompanying sketch at top of page, which breaks off when an overload is thrown on the feed.

In another instance the repair man in a factory manufacturing valves and fittings had considerable trouble with threading machines jamming, due to an imperfect casting which would be too heavy for a tap or die to cut; here the threading was done on the unmachined castings.

At the first opportunity this repair man put a breaking piece on one of the machines, but instead of a taper pin he used a small piece of flat steel which was set half in each of two collars on a mainshaft on the machine. The cross-section of this strip of steel is small enough to allow it to shear off before any damage occurred elsewhere. The plan was very successful and now all these machines are so equipped.

Not long ago the writer saw a multiple semi-automatic filing machine with a simple and effective shear link. This machine was back-geared and the link was placed on the first shaft between the main pulley, which was not keyed to the shaft, and a collar keyed to the shaft, as shown in the sketch at bottom of page. The links were held in position by a circular spring clip of flat steel which was snapped around the hub of the collar. The ends of this clip were open about an inch. Turning the clip on the hub covered the link and held it in the slot or exposed the slot so that the broken link could be removed and the new one inserted.

In case a file jumped out and caught (as was sometimes the case), the pin broke. Otherwise the operator would have had the trouble of replacing a large belt on an overhead shaft 18 ft. above the floor. The operator of the machine had a supply of these links, which he could replace as quickly as he could replace a file because of the simple arrangement for holding them firmly in place.

Care must be exercised to see that the operators understand and appreciate the value of these links and do not put something in that will not break which would be the same as replacing a blown fuse with a piece of steel wire. Making it easy to replace the shearing pin or having a supply of such pins convenient, if the operator is to replace those broken, will help to insure their proper use.

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In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Mixture for Protecting Commutator V-Ring Insulation from Oil

THREE years' experience of a large repair shop in the use of a mixture of plaster of paris and dextrine as an oil resisting paste to prevent the disintegration of the varnish by oil on the outer V-ring insulation of the commutator, has shown that the number of armatures coming to the shop with grounded front V-rings has been greatly reduced.

The mixture used is composed of dextrine and plaster of paris in equal proportions, with just enough liquid shellac to give it the correct consistency. It should be made thick enough to be applied with a brush, although it is much thicker than paint and other substances usually applied with a brush. A coating about $\frac{1}{16}$ in. thick is applied to the front V-ring of the commutator.

Emergency Method of Making an Insulation Trimmer And Wedge Driver

WHILE on a repair job that involved taking out some of the coils of a 1,000-kw. generator and replacing them with new ones, I discovered to my displeasure that I had no wedge driver or insulation trimmer. To cut the insulation between the top and bottom coils is quite a job with the ordinary knife or insulation trimmer. For this reason, I made a trimmer which worked so well that I have kept it ever since as one of my regular tools.

As shown in the illustration, this

This insulation trimmer was made of banding wire and a copper lug.

insulation trimmer was made from a piece of No. 10 steel banding wire about 2 in. longer than the width of the stator iron. On one end of the wire I soldered a 125-amp. copper lug or terminal to serve as a handle. The other end of the wire was flattened and made into a V-shape, as shown. This V-shape edge was then filed to form a cutting edge.

The wedge driver was made from a piece of brass tubing about 1 in. inside diameter and $1\frac{1}{4}$ in. outside diameter. By figuring out the inside circumference of the brass tubing you will be able to get a close approximation of the correct size of the material to use as the center piece of the wedge driver. For this center piece I used fiber having a $\frac{1}{2}$-in. x $\frac{3}{8}$-in. cross-section. The brass tube was then hammered down to fit snugly around the fiber. A neat job can be made if a little care is used and the wedge driver will be found to be as good as any you can obtain. However, you must remember to work the brass tubing cold for if it is heated the tubing is very likely to crack.

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Method of Changing Compound Motor to Special Series Type

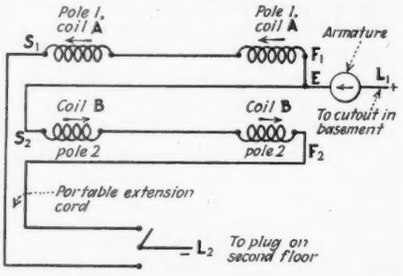
THE requirements for a certain power drive were such that it was necessary to start, stop and reverse it at some distance from the motor. It was found that a $\frac{1}{4}$-hp. motor would be satisfactory, but the customer wanted a single-pole, double-throw knife switch with a two-wire lamp cord, running from the motor for control. This was to make it easy to install and remove. It was also decided that this was a job for a series motor, which would give good torque and also permit the use of a double series field winding for two-wire control.

In the shop we had a $\frac{1}{4}$-hp., 115-volt, compound-wound motor whose fields were roasted out; so it was decided to rewind the field circuit, for the rest of the motor was in good shape. The full-load rating of this motor was $2\frac{1}{2}$ amp. and the factory data gave the resistance of the two shunt coils in series as 556 ohms. Each shunt coil had 3,250 turns of one No. 30 enamel-covered wire, and each series field coil had 31 turns of one No. 20 d.c.c. wire.

The next step was to find the ampere-turns per pole. With 556 ohms across 115 volts, there would be in the shunt field circuit 115 ÷ 556 = 0.207 amp., and the shunt ampere-turns per pole would then equal 0.207 × 3,250, or 672.75. Similarly, the series field ampere-turns equal 31 × 2.5 or 77.5, and the total ampere-turns equal 77.5 + 672.75, or 750.25 ampere-turns per pole. For the series field coil to develop 750 ampere-turns at $2\frac{1}{2}$ amp., it would require 750 ÷ 2.5 = 300 turns per coil.

No. 20 wire was originally used for the series coils, but this was for constant duty, whereas for the new service, a double series field coil, for intermittent duty, and there would be need for all the wire space we could get. Since the wire size could be reduced, we decided to use No. 22 s.c.c. and enameled wire and wind two coils for each pole, each coil to have 300 turns. These two coils were to be taped together and four leads brought out. After assembling the coils on the two poles, they were connected up in two sections, each section consisting of two coils in series as shown in the diagram.

Next, the beginning of one section,



The motor was provided with a double series field so that it could be reversed by a single-pole, double-throw knife switch.

S_2 was connected to the finish of the other section F_1 and from their junction a tap was brought over to one brush-holder, as at E. The other brush-holder was connected to the lighting circuit L in the basement.

The lamp cord was connected to the remaining two field leads S_1 and F_2. The other end of the lamp cord was carried up to the second floor and connected to the outside points of the single-pole, double-throw switch, as shown. The middle point of this double-throw switch was connected to a single line to which an ordinary attachment plug was connected, thus leaving one prong of the plug unconnected. A plug was put in a light socket on the second floor and the plug, with one wire from the double-throw switch was tried in this socket. At the first trial the motor did not start, but by reversing the plug in the socket, the circuit was completed. By marking the plug while in this position we were able to replug the socket in the same position every time.

Then, by throwing the single-pole, double-throw switch to the left, the conditions were as indicated by the dotted-line arrows in the accompanying drawing. This reversed the polarity of the poles by sending current through the field coils of section S_1 and F_1, in the

opposite direction to the current flow in section S_2 and F_2. Since the current through the armature remained the same, the rotation was reversed. By marking one side of the single-pole switch open and the other side closed, a simple and effective control was obtained.

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Motor Life Increased by Dipping Coils and Baking in Electric Oven

AN INCREASE of 75 per cent in the life of motors which have been dipped and baked is not uncommon. The practice of dipping the coils of electrical equipment in an insulating varnish and baking them before placing in the machine, and then dipping and baking the complete winding, has become quite general practice in the electrical manufacturing industry and in repair shops. The Power Committee of the National Electric Light Association recently issued a report entitled "Baking Armatures and Insulated Coils in Electric Ovens." In this report it is stated that the practice first demonstrated its real value, in making savings and promoting the reliability of electrical machinery, on railway-motor armatures. Besides the direct saving involved by the dipping and baking process, there is the great gain due to fewer breakdowns in service which fact is in itself a major consideration.

The reason for the longer life and improved reliability of coils and windings that have been dipped and baked, is that the insulating varnish, properly applied and baked, forms a hard coating, impervious to moisture, which fills all the cracks and crevices, holds loose coils and laminations in place, restores coil insulation to good condition and prevents the entrance of dirt and moisture.

Proper treatment of coils and windings involves three factors: (1) Use of suitable baking varnish. (2) Thorough impregnation of the coils. (3) Uniform baking of the coils at the correct temperature.

A large part of the report is devoted to an extract from an A.E.R.A. paper, "Certain Essentials in Drying and Baking Railroad Armatures," by H. S. Day. Although this paper dealt with railway armatures, it contains much that applies equally well to industrial equipment.

The object of dipping an armature in an insulating varnish and then baking dry is to encase the wires and coils in a hard, gum substance that will, by completely surrounding the coil, prevent chafing, lessen vibration and repel moisture and oil, all of which would in time break down the original insulation and be the principal cause of grounds or short-circuits.

Three important precautions that must be observed during the process of dipping and baking are: First, the armature must be free from all dirt and moisture; second, all windings must be thoroughly saturated with varnish and the surplus drained off; and, third, the varnish must be baked dry.

To dip in varnish an armature that is not clean and dry is to defeat one's purpose at the start, because dirt and moisture trapped in windings by hardened varnish will quickly cause insulation breakdowns. The same criticism applies to the dipping of all wires and coils, for if they are not thoroughly saturated with varnish the desired result is again defeated, because it allows open spaces for the accumulation of oil, dirt and moisture.

Finally, and undoubtedly most important, if the varnish is not baked dry the coils are simply supplied with moisture before the motor has a chance to pick it up.

The universal practice in cleaning an armature preparatory to dipping is to blow the dirt out with air pressure, and this is probably the most practical, but the air must be dry air. After the dirt is all blown out, an excellent practice is to dip the armature in a vat of gasoline and move it around until all oil and dirt are removed. After the armature is cleaned, it should be placed in the oven and kept there for 10 to 12 hr. at a constant temperature just high enough to dissipate moisture that is in the coil insulation.

At the end of the preheating period the armature must be allowed to cool off, so as not to enter the varnish too hot. The correct temperature is from 55 to 60 deg. C. (130-140 deg. F.), or when a workman can comfortably lay his hand on the core. The reason for this is that if the armature is too hot the varnish will be heated, become too thin and run off, leaving the armature with too thin a coat of varnish. For the same reason the container for the varnish should be large enough to hold two or three barrels of varnish. This volume, on account of added weight, also helps in forcing the varnish further into the coils.

There are many different opinions as to how the armature should be dipped, and whether it should literally be dipped at all. But there is one point about which there cannot be any argument, and that is that the windings should be thoroughly saturated with varnish. The simplest and easiest way is to immerse the armature up to the commutator ears in a tank of varnish, with the pinion end down, for a period of 5 to 10 min.

After this operation is completed, the armature should be removed from the varnish and all free varnish drained off. In some armatures this is a little difficult to do. It may be necessary to sling the armature from both ends of the shaft and elevate first one end and then the other, at the same time giving it a few turns, continuing this operation until all the free varnish has run off. Ordinarily the average armature will drain properly if set upon the pinion end of the shaft and allowed to stand 10 or 15 min. The important thing is to get rid of the free varnish, so that there will be no pockets of wet varnish to cause trouble during the baking period.

Equally as important as having the armature at the right temperature when it is placed in the varnish, is to have the varnish at the right specific gravity. About the most practical way of ascertaining the correct specific gravity is to use a hydrometer. Most varnishes can be thinned or, as it is called, "cut" by the use of gasoline or benzine. This should be added in small quantities and stirred in, because if a large amount of gasoline is added at one time curdling of the varnish may result. Gasoline or benzine that has a low kerosene content should be used, as when the kerosene content is high the oil is left when the gasoline is evaporated during the baking period. Gasoline to be used as a cutting agent should test not less than 54-46 deg. Baumé.

By using a hydrometer the uniformity of the varnish can easily be controlled. This is necessary if the results are to be uniform. Having once established that specific gravity which gives the best filling results and the best penetration, any deviation from that point will result in a loss of one or the other of these characteristics.

When the armature is drained it should be placed in an oven in which the temperature generally recommended is not allowed to vary either below 115 deg. Cent. (239 deg. F.), or above 125 deg. C. (257 deg. F.), and kept there without interruption until the baking period is over. It is an excellent practice if the armatures are placed in a horizontal position to turn them every 10 to 15 min. during the first hour before the varnish is set. This will prevent what free varnish is left from collecting in one spot.

The oven must be ventilated sufficiently to carry off the moisture and gases given off in the baking process without lowering the temperatures, and the baking period should be uninterrupted; that is, the oven not cooled down until the varnish is dry.

The varnish must be baked dry, whatever the time required, and the baking time is, of course, governed to some extent by the oven temperature. A simple way to know when an oven is baking armatures dry is to measure the insulation resistance during the baking period.

This should at least be done in starting a new oven, and from time to time until the operator has established standards and becomes thoroughly familiar with every detail that is connected with this process.

There are two types of baking varnish, one having a Chinawood oil base, and one a linseed oil base. Varnish with a linseed oil base will not give as good results as a combination varnish containing a larger proportion of Chinawood oil than linseed oil. This is a matter for the operator to decide by the results obtained. The same thing may be said in choosing between amber and black varnishes, although it is believed that more gums and non-volatile insulating substances, such as asphalt, can be suspended in the black varnish. The important thing is to select a varnish that is known to be high grade and is made for the specific purpose of being baked on coils.

Ovens should be thermostatically controlled to insure a constant temperature during the baking period because if controlled by hand and left to an operator the heat control will be frequently forgotten or neglected, and it is important that this should not happen for otherwise the quality of the insulation will be impaired.

Practical Books
for your personal library

Every man who aspires to larger responsibilities should build up a professional library containing carefully selected volumes on subjects related to his work. Copies of the books which are reviewed here may be obtained from the publishers mentioned.

Electric Transients—By Carl Edward Magnusson, Professor of Electrical Engineering and Director, Engineering Experiment Station, University of Washington. Published by McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N. Y. Cloth; 6 x 9 inches; 237 pages; illustrated. Price $3.

The purpose of this book is to aid the student in gaining clear concepts of the fundamental principles underlying transient electric phenomena and their application to quantitive problems. The text is illustrated and supplemented by a large number of oscillograms of transients that occur in the various types of machines and electric circuits in common use in electrical engineering laboratories.

* * * *

Belt Conveyors and Belt Elevators—By Frederick V. Hetzel, M.E. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. 333 pages; 6 x 9; illustrated. Price $5.

In this, the second edition of this book, the author presents his experience in such a form as to be useful to men who have material to handle and who want to know more of the how and why of conveying and elevating by belts, than can be told in catalogs and advertisements.

The information given will be of use also to consulting engineers who have to advise in the selection of the proper machinery to do certain work, to engineers and draftsmen who design such machinery, and also to students in technical schools and colleges.

* * * *

Industrial Safety Organization—By Lewis A. DeBlois, Director, Safety Engineering Division, National Bureau of Casualty and Surety Underwriters. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y. Cloth; 6 x 9 inches; 328 pages; illustrated. Price $4.

This book presents a thorough, practical discussion of the fundamentals and basic principles of safety organization. The purpose is to furnish industrial executives with information about the industrial safety movement and the essential principles of safety work needed for successful accident prevention. It aims also to provide safety engineers with a technique based on sound and logical principles.

Fourteen years of accident prevention work in the du Pont Company, where safety organizations were developed from modest beginnings in numerous small plants to full-fledged safety departments competent to function satisfactorily in huge war-time establishments—these later to pass through successive stages of retrenchment and expansion—have permitted the author to make a broad survey of safety systems and methods, successful and otherwise.

* * * *

Electrical Characteristics of Transmission Circuits—Compiled by William Nesbit, Manager, Engineering Division, New York Office, Westinghouse Electric & Manufacturing Company, published by Westinghouse Technical Night School Press, East Pittsburgh, Pa. Cloth; 9 x 12 inches; 317 pages; 102 tables; 28 charts; 100 figures. Price $6.

The rapid expansion in the use of electrical energy necessitates a tremendous amount of arithmetical labor in connection with the solution of projected transmission and distribution circuits. This demands much valuable time and energy of the engineer, and in the education of young engineers in our technical schools. It is largely to assist these by making their work easier and less liable to error, and by providing them with all the necessary tools, that the data in this book have been compiled.

The user of this book is provided with numerous and extensive tables of circuits and other constants which make it unnecessary for him to lose time or risk mistakes in calculating constants for each case in question. Every effort has been made to simplify explanations by the aid of supplementary diagrams and tabulations.

* * * *

Engineering Metallurgy — By Bradley Stoughton, Professor of Metallurgy, Lehigh University. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York, N. Y. Cloth; 6x9 inches; 441 pages; illustrated. Price $4.

In this, the first volume of the new series of metallurgical texts, the subject of metallurgy is approached from the standpoint of utilization, with the purpose of giving the reader an understanding of the relations of structures and properties, methods of investigating them, their relation to uses, their modification through mechanical and heat treatment, the effect on them of the principal impurities, and the effect on them of differences in production processes.

This is a practical book and is in reality a textbook for users of metals, and is well worth while for the men interested in this subject.

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Standard Wiring—By H. C. Cushing. Published by H. C. Cushing, Jr., 15 West Fiftieth Street, New York, N. Y.

In the November issue of INDUSTRIAL ENGINEER, the price of this book was quoted as being $2.50 per copy. This price applies only when lots of two to four copies are purchased. The price per single copy is $3.

New Equipment
for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Heavy-Duty Chain Belts

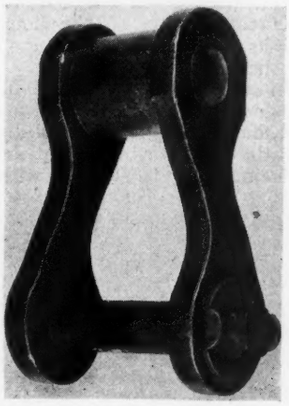
TWO new oil well chains for heavy-duty service, with the trade name of Rex Deep Well Chabelco 1240-D.W.4 and 1030-D.W.3, which have a new type of pin lock and high tensile strength, together with ground pins and ground bushings, have been announced by the Chain Belt Co., Milwaukee, Wis. The rated strength of these chains is given as 90,000 lb. for the 1240-D.W.4 and 45,000 lb. for the 1030-D.W.3. This represents an increase of 25,000 lb. in 1240 and 15,000 lb. for the 1030 over the old chains of that number, although the new chains are of the same weight and pitch as their predecessors, it is stated.

The Rex pin lock offered on these chains is said to be entirely new and is designed to replace the cotters ordinarily used. In oil well drilling and similar heavy-duty service the cotters, in a relatively short time, either break or jump completely out of the chain. The pin then works loose rapidly from the drive fit with which it is seated in the sidebar. The new Rex pin lock, it is stated, is as simple to use as the cotter. It consists of a disk which fits over the link pin, which is a short spring pin that is slipped through the hole in the link pin and secured at each end by bending up the two metal ears on the disk. This construction is easily seen in the accompanying illustration.

The link pins have also been improved; the drop-forged steel pins are ground on a centerless grinder and the bushings are made from seamless drawn tubings. The natural action of the chain, according to the manufacturer, is freer, friction is reduced, and the wearing qualities of the chain are

increased by bringing these smooth surfaces together. The ground pin allows much closer fitting of the pin and bushing and the ground bushing and the roller also operate with closer clearances. The bushings have one flat milled on each end and are forced into the sidebars under pressure.

With the smooth surfaces of both



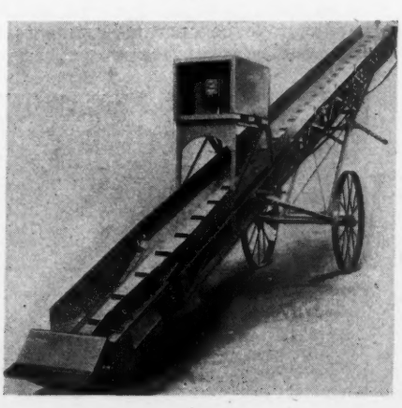
the pins and sidebars, the manufacturer states that it is not necessary to make allowances for variation or rough spots either in the pins or in the interior so that while these chains are more flexible, the pitch is far more accurate. The results claimed for this construction are longer life and correct distribution of strain and stress between the chain, sprockets, and other working parts that are chain driven. All parts are heat-treated.

Improved Portable Conveyor

AN IMPROVED type of portable belt conveyor for handling sand, gravel, crushed stone, bricks, coal, coke, and similar materials has recently been put on the market by the Jeffrey Manufacturing Co., Columbus, Ohio. Improvements have been made with the idea of providing a machine more suitable for industrial plants and building material yards, where it is desired to handle materials from hopper bottom railroad cars to storage piles or trucks, and for reclaiming from storage piles.

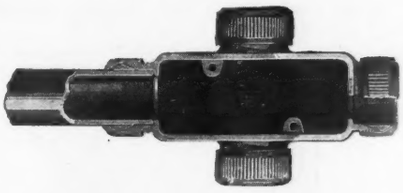
Four new features are incorporated in this new conveyor. Steel side boards, which are bent to extend under the side of the belt, forming with the belt a moving trough, provide larger capacity and prevent lumps from rolling off. An improved type of carrying idler supports the loaded portion of the belt. An extended and flared loading leg at the bottom edged with belting forms a seal with the moving belt. The flared hopper also centers the load on the conveyor. An efficient gate at the foot of the conveyor prevents materials from falling into the inclosed boot housing.

An easily-operated screw adjusts the elevator to any convenient height. The foot of the conveyor is so low that it will readily enter a pile of loose material. The conveyor is built in 18-, 24- and 30-ft. lengths, and is furnished with an electric motor or gasoline engine.



No-Thread Unilets

IMPROVEMENTS in its line of No-Thread Unilets have been announced by the Appleton Electric Co., 1701 Wellington Ave., Chicago, Ill. These will be manufactured as an addition to the line of threaded Unilets made by this company. No-Thread Unilets of a different design were made by this company more than 15 years ago and the new line, it is stated, shows many decided improvements over the old. There are no loose parts. To install, according to the manufacturer, it is only necessary to cut the conduit, slip it into the No-Thread Unilet, tighten



the knurled nut, which insures a mechanically secure joint, a running ground and a strong job, in considerably less time than is ordinarily required.

The accompanying sectional view of this improved Unilet shows its design. The tapered steel ring is squeezed into the conduit by the knurled nut. This same ring has on its inner surface three projecting beads that pierce through the conduit enamel, thus establishing a metal-to-metal contact and insuring a perfact running ground, it is stated. All standard Unilet covers and fittings are interchangeable with the No-Thread Unilets.

Armature Feeler Gage

A NEW feeler gage has been placed on the market by C. A. Parkham, Inc., 526 W. Fort St., Detroit, Mich., for use in checking the gap between stators and rotors.

The feeler stock is manufactured from imported Swedish tempered steel feeler stock, which is represented as having an accuracy to within 0.0001 in.

The blades and handle are each 16 in. long, making an overall length of 32 in.; the blades are 0.06, 0.08, 0.010, 0.015, 0.025 in. in thickness. Should it be necessary to replace a blade it can be easily removed by loosening a screw in the handle.

Heavy-Duty Belt Clamp

CLAMPS of a new design for joining fabric base belts in heavy-duty service have been announced by the Victor Balata & Textile Belting Co., 38 Murray St., New York, N. Y. These are known as the Petrol belt clamp and were originally developed to increase the life and service of oil well drilling

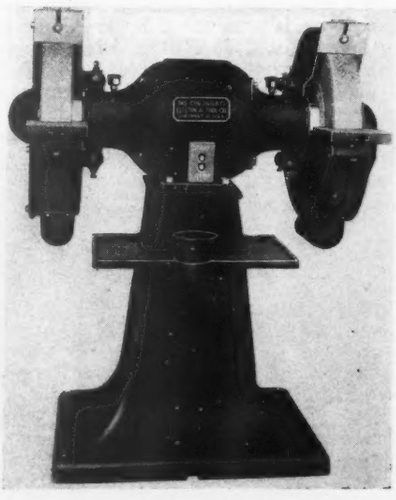
and pumping belts which operate under extremely severe service. These clamps are also used for exceptionally severe industral service.

The type of clamp and its application are shown in the accompanying illustration. The clamps are made of steel forgings and are bolted together with carriage-style bolts, hexagon nuts and lock washers. The clamp and fittings are galvanized. Corrugations on the jaws of the clamp give a better grip on the belt, it is said, and so help to prevent tearing. Also, the clamps are curved at the angle. This, according to the manufacturer, prevents the clamp from cutting the belt and also avoids misapplication.

Fully-Enclosed, Heavy-Duty Floor Grinder

THE Cincinnati Electrical Tool Co., Cincinnati, Ohio, has recently added to its line of portable electric drills, grinders and buffers, new 2- and 3-hp. fully-enclosed, heavy-duty, ball-bearing, floor grinders suitable for grinding of all kinds.

The ball bearings are mounted in dustproof housings, and it is stated, are correctly locked to the shaft to provide for end thrust and eliminate shaft wear. The spindle is of high-grade steel turned and accurately ground to size. Wheel flanges and nuts are machined to be in perfect balance with the spindle. Removable covers bolted to the guard completely enclose the side

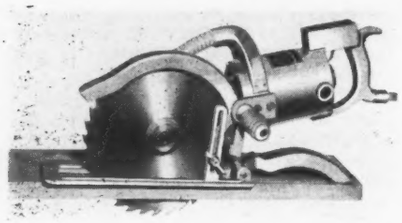


of the wheel, flanges and nuts, insuring safety to the operator. The 2-hp. grinder is equipped to carry 12-in. by 2-in. by 1¼-in. wheels and the 3-hp. grinder, 14-in. by 2½-in. by 1¼-in. wheels.

These grinders may be obtained for operation on either alternating current, 220 or 440 volts, 25 to 60 cycles, two- or three-phase, or direct current, 115 or 230 volts.

Electric Hand Saw

INDUSTRIAL plan men and contractors who have occasion to do more or less sawing of wood outside the wood shop will be interested in the announce-



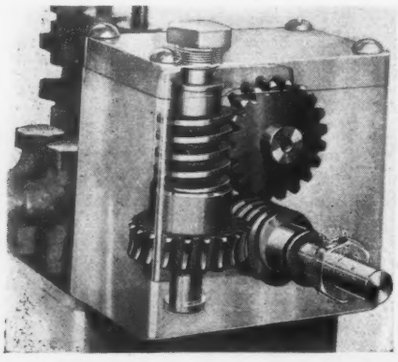
ment of the Wodack Electrical Hand Saw, shown in the accompanying illustration, which is manufactured by the Wodack Electric Tool Corp. located at 23-27 South Jefferson Street, Chicago, Illinois.

This electric tool weighs 24 lb. and is fitted with a motor which is said to be large enough to drive an 11-in. circular saw and yet can be operated from an electric light socket. Industrial men are finding use for this saw it is stated, for removing flooring; electrical construction men are using the saw for cutting a channel in the floor in which to lay conduit, and many other uses are reported, such as for concrete form work, in the shipping room, and so on.

The saw is fitted with a depth gage so that the depth of the cut can be closely controlled, as when cutting through a floor or opening a box or crate.

Fractional Horsepower Worm Reducers

COMPLETION of the design and the marketing of a ½-hp. worm speed reducer is announced by the Hills-McCanna Co., 2025 Elston Ave., Chicago, Ill. A phantom view of one of the double-reduction units is shown in the



accompanying illustration. This equipment was originally designed for use in connection with the drive of the Hills-McCanna force-feed lubricating system. The 20: 1 and 30: 1 reduction units are made in the single-reduction worm and gear types. A double combination of worms and gears is used to obtain reductions of 50: 1, 100: 1, 200: 1 and 400: 1.

The manufacturer states that standard, hardened steel worms running against bronze worm gears are used. The whole mechanism is enclosed in a grease-packed, dustproof case measuring 4 in. by 4 in. by 2⅞ in. The case is provided with stuffing boxes to retain the grease. A ½-in. shaft is provided for connecting to a motor through a flexible coupling or for belt drive.

Rapid-Heating Melting Pots

AN ADDITION to the Trent line of rapid-heating melting pots manufactured by Harold E. Trent, 250-261 N. Lawrence St., Philadelphia, Pa., is shown in the accompanying illustration. This pot, it is said, is suitable for melting babbitt, solder, lead, and tin, and has a capacity of 10 lb. The pot is for use on 110 or 220 volts, a.c. or d.c., and can be connected to a lamp socket. A new feature of this equipment is that a new design of protected plug contact has been added whereby

a standard plug can be used to obtain the three-heat combination.

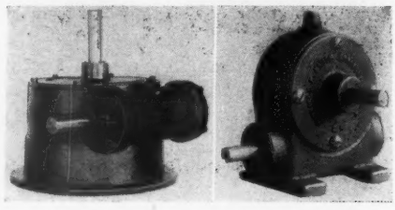
All pots are fitted with spouts and two handles to facilitate pouring metal, if so desired. The crucible is insulated to give high heat efficiency, according to the manufacturer.

Reducing Gears of Small Capacity

ANNOUNCEMENT is made that Winfield H. Smith, Springville, N. Y., has added two new uits to his line of reducing gears of small horsepower capacity. One of the new models is the No. 8 vertical-drive, worm gear reduction unit, which is shown in the accompanying illustration above. The same reductions of 40:1, 20:1, or 10:1 can be furnished as are standard with the horizontal-drive, No. 8 reducing gear. Ratings for the various reductions are 2, 3 and 5 hp. respectively, at 1,800 r.p.m. of the worm shaft. The illustration shows the driven shaft extended at the top, but if desired the shaft can be extended and the drive taken from the bottom. This type of drive is used, it is said, in connection with mixing machines, agitator tanks, turntables, and so on.

The other new reducing gear, shown at the right is the No. 2½ unit, which is made for use with motors up to ⅓-hp. capacity. Standard units are built to give a reduction of 40:1. The unit is 5½ in. high from the bottom of the base to the top of the housing and weighs 8 lb. Bronze bearings are used for the high-speed shaft.

In addition, the standard No. 3 reducing gear has been redesigned as the No. 3 A, but all of the essential dimensions are the same as in the old unit. This reducing gear is for use with motors

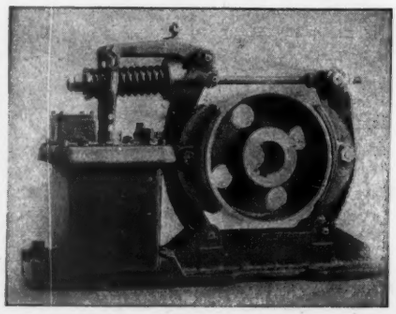


up to ⅝-hp. capacity. Reductions of 20:1, 10:1 and 5:1 are standard and units are carried in stock for immediate shipment.

New Magnetic Brakes

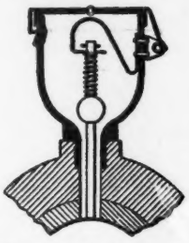
TWO new magnetic brakes, types DI and AI, are being manufactured by the Westinghouse Electric and Manufacturing Company for both direct-current and alternating-current service. In addition to being spring-set and easily adjustable, these brakes have unusually small dimensions, a distinct advantage for industrial applications. The small diameter of the brake wheel requires less power to operate and less time for starting and stopping.

A weatherproof cast-steel housing for the magnet, is another feature of these brakes. The magnet and coil unit are protected against damage and the weather. Ample ventilation is provided for by hooded openings in the cover of the housing, and cored holes in the base. The complete magnet can be removed from the brake by simply taking out one pivot pin and loosening two bolts in the tapered blocks, and a new magnet substituted in a very short time. With this design the same equipment may be used for both alternating-current and direct-current work by merely changing the magnet. A manual release enables the motor to be operated without the brake during inspection or test.



Grease Lubricator

EXPERIMENTAL and development work have been completed on the Knorr lubricator which is shown in the accompanying illustration, according to an announcement by the Knorr Lubricator Sales Co. of New England, 80 Federal St., Boston, Mass., and distribution to industry is now under way. This lubricator consists of a cup with a spring cover to contain the grease. The lubricant is fed down to the shaft between the pin and the oil hole by the movement of the pin, which rests on the shaft, due to the eccentricity of the shaft. The spring on the pin maintains contact with the shaft. This device, it is stated, feeds the grease much in the same manner as the bottle oiler feeds oil. An advantage claimed is that feed of the lubricant takes place only while the shaft is in motion, and in a degree corresponding to the speed of the shaft.



Mica Insulation

A NEW mica insulation, called "Super-micanite," has been developed by the Mica Insulator Company, 68 Church Street, New York City. The development of a synthetic insulating cement, a resin produced from glycerine and phthalic anhydride, which possesses electrical and chemical characteristics particularly advantageous as a cement for mica insulating materials, has resulted in the further development of "Super-micanite." This new insulation is said to be ideally adapted for commutator insulation.

The outstanding advantages of "super-micanite" as compared with shellac-pasted mica are listed by the manufacturer as follows: It is non-corrosive to copper; its binder decomposes at high temperatures and then produces decomposition products which are neither corrosive nor conducting; it shows practically no slippage under pressure; its surface resistivity is approximately 350 per cent greater; it has higher dielectric strength; its loss factor is approximately 43.5 per cent of that of shellac-pasted mica; its volume resistivity is approximately 92 per cent higher; it has a greater resistance to moisture; it has more compressive strength than shellac-pasted mica up to 100 deg. C.; it has a lower moisture content and a greater transverse strength.

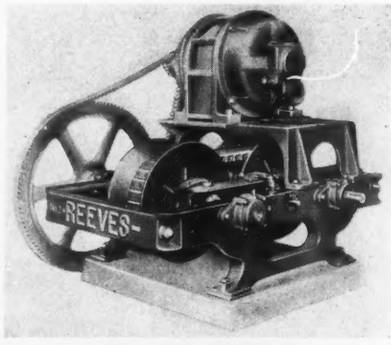
Variable-Speed Transmission

TWO new variable-speed transmissions have been added to the line of this equipment manufactured by Reeves Pulley Co., Columbus, Ind. The first, as shown in the upper illustration of Fig. 1, consists of a constant-speed motor mounted on and above the Reeves variable-speed transmission and connected to the input shaft by a silent chain. This not only makes a compact installation, but conserves floor space in that it is not necessary to mount the motor on the floor alongside the transmission or drive down from the ceiling. This motor mounting is slotted and, it is said, will accommodate any standard type of motor of the proper size for the drive. Adjustments can be made by means of the slot to give the proper tension on the chain drive.

This unit is marketed under the name of Reeves Compact Motor Drive. The unit is ball-bearing equipped and force-feed lubricated. The transmission receives power at a constant speed and delivers that power at any speed desired between the rated fastest and slowest speeds over a range as high as 16:1. By means of clutches or an extra shaft this ratio may be increased. The speed may be maintained at any set point or varied manually or automatically. The unit may be mounted on the floor, or built into the machine.

For installations where space is too limited for the use of the Reeves Compact Motor Drive, the vertical type of transmission shown in the lower illustration of Fig. 1 was developed. The shifting screw is generally located at the top of the drive and the speed may be varied either manually or automatically and the speed indicator used, as is standard with all types of Reeves transmission.

The improved type of splice blocks shown in the other illustration, facilitates the removal or application of the standard, rubber body V-belt to the transmission. The V-belt is made up of a rubber belt body to which is attached at regular intervals hardwood blocks, tapered at both ends and faced with leather to conform to the V-angle of the disks. As shown in this illustration the splice block is made up of two half-sections of the block with hinge plates at each end of the belt. These hinge plates are screwed to the blocks at each end and secured by inserting pins through the eyes of the hinge. Corresponding hinges are attached to the tooth side of the block as well as to the belt side.



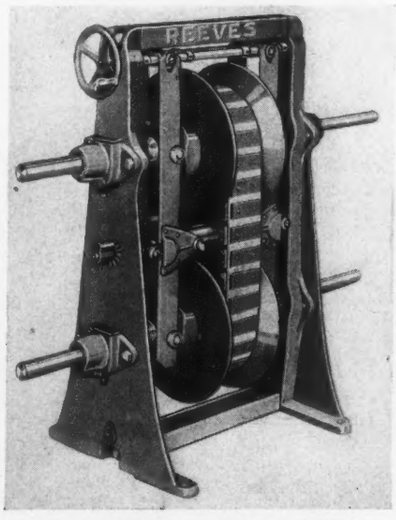


Fig. 1—Above, Reeves Compact Motor Drive. Below, vertical type transmission

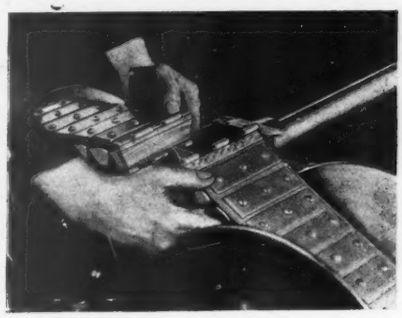


Fig. 2—Improved type of splice block manufactured by Reeves Pulley Co.

Self-Starting Squirrel-Cage Motor

DEVELOPMENT of the type H-O (Hanson-Oesterlein) self-starting squirrel-cage motor, has been announced by the Northwestern Mfg. Co., Milwaukee, Wis. This motor has a single rotor winding with the rotor bars near the surface, thus giving a minimum magnetic leakage, it is stated. The rotor bars are connected at the ends to low-resistance, arc-welded, copper end rings. These are partly surrounded by steel laminations. For motors requiring a high starting torque high-resistance end rings are placed next to the rotor core. During the starting period the high impedance in the low-resistance end rings prevents the flow of current in them and forces it through the high-resistance end rings, thus producing a high starting torque, according to the manufacturer. As the speed increases the impedance in the low-resistance end rings decreases and the total torque increases until the rotor reaches full speed.

These motors are built regularly for two torque ratings. The type H-O-L, it is stated, has a 130 per cent starting torque and is suitable for motor-generator sets, centrifugal pumps, fans or for any machinery requiring low starting torque. The type H-O has a 200 per cent starting torque and is used for driving air compressors, refrigerating machines, plunger pumps and other machines requiring high starting torque. The rating is 40 deg., continuous duty. It is stated that a single-throw switch may be used for starting small motors and a push-button-operated switch with overload and no-load protection for 15-hp. and larger motors.

Power Transmission Association Elects Officers

THE second general meeting of the Organization Committee of the Power Transmission Association was held Wednesday, November 17, at the Pennsylvania Hotel, New York, N. Y., with representatives present from a large number of leading manufacturers of mechanical power transmission and allied equipment.

W. H. Fisher, chairman of the Organization Committee, presided and after the meeting had been called to order introduced Frazer M. Moffat, president of the Tanners Council of America and E. J. Mehren, vice-president of the McGraw-Hill Publishing Company, who spoke briefly on the ideals and purposes of trade associations, and their value in promoting closer co-operation in the solution of problems that are of mutual interest.

Chairman Fisher then presented the report of the Organization Committee, in which it was shown that a great deal of interest had been evinced in the purposes of the Association by manufacturers in this industry, and that to date 104 companies had signified their intention of joining. The report also contained recommendations covering the form of organization which it was felt would be most suitable for this Association and proposed a schedule of dues for member companies.

After the reading of the report, there was some discussion as to the advisability of having the Organization Committee continue its work, so that a larger number of members could be secured before the Association proceeded to carry out its program. When this question was put before the meeting, however, it was unanimously voted to put the Association on a permanent basis and have it undertake active work at once.

Upon receipt of the report of the Nominating Committee appointed by the Chairman, the following officers were elected:

President. W. H. Fisher, secretary and sales manager, T. B. Wood's Sons Co.

Vice-presidents, representing,

Leather Belting Manufacturers, F. H. Willard, president, Graton & Knight Mfg. Co.

Tanners and Curriers, Edward D. McKown, vice-president, Hans Rees' Sons Co.

Power Transmission Equipment Manufacturers, Geo. H. Miller, president, Dodge Mfg. Corp.

Pulley Manufacturers. Wm. R. Simpson, vice-president, The American Pulley Co.

Hanger Manufacturers, S. A. Ellicson, president, Chicago Pulley & Shafting Co.

Accessory Manufacturers, Wylie K. Lee, president, Clipper Belt Lacer Co.

Fabric-base Belt Manufacturers, B. J. Kielly, president and general manager, R. & J. Dick Company.

Treasurer, L. H. Shingle, president, Shingle-Gibb Leather Co.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Service Switches—A booklet describes type WK-54 Westinghouse meter service switches.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Transformer Tap Changer—Bulletin 2055 describes and illustrates the construction and operation of the Pittsburgh transformer tap changer.—Pittsburgh Transformer Co., Pittsburgh, Pa.

Motor Maintenance Equipment—In Catalog No. 7 there are descriptions and illustrations of the various types and applications of equipment used in motor maintenance.—The Martindale Electric Co., P. O. Box 2660, Cleveland, Ohio.

Paint and Painting Equipment—Leaflet VA-1 describes Vortex industrial paints and illustrates the application of the mechanical painting equipment.—The Vortex Manufacturing Co., 1978 W. 77th St., Cleveland, Ohio.

Circuit Breakers—Leaflets L 3549-B, L 20135-A, and L 20011-A discuss the application, construction, and operation of types CA, CL and CN carbon circuit breakers, and types F-11 and F-22 oil circuit breakers.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Starting Equipment—Bulletin 600 describes the Allen-Bradley primary resistance starters. Bulletin 710 describes the type J-1552, form T, across-the-line starting switch. Bulletin 740 describes the type J-3052 automatic resistance starter.—Allen-Bradley Co., Milwaukee, Wis.

Waterproofing and Damp-Proofing Concrete—Folder No. 2 gives complete descriptions and detailed specifications of waterproofing, damp-proofing, and allied products for use with mass concrete and cement mortar, or for surface application.—The Master Builders Co., Cleveland, Ohio.

Controls—The fourth issue of Mill Motor Gossip describes and illustrates, Clark magnetic brakes, flexible couplings, manual controllers, starting switches, and resistors, with references to bulletins containing more complete information.—The Clark Controller Co., 1146 E. 152nd St., Cleveland, Ohio.

Skip-Lift—Bulletin 79 describes and gives the operating features claimed for the Beaumont Skip-Lift for handling granular materials, such as coal, stone, and so on, in bulk. Numerous sketches and illustrations show typical installations under a wide variety of conditions.—R. H. Beaumont Co., Philadelphia, Pa.

Portable Grinders—Nos. 2, 3, and 4 ball-bearing, floor-type, electrically-operated grinders are described and illustrated in Circular No. 36.—Binghamton Flexible Shaft Co., 239-241 Water St., Binghamton, N. Y.

Air Filters—The advantages and necessity for pure air are discussed and Sirocco air filters described and illustrated in Bulletin No. 2223.—American Blower Co., Detroit, Mich.

Electric Hammers—Simbi hammers together with their various applications, are described and illustrated in Bulletin 106.—The Rawlplug Co., Inc., 66 W. Broadway, New York, N. Y.

Hand Lift Truck—A circular entitled "Multiplying Men" describes some of the features of construction of the model K Stuebing all-purpose, hand-lift truck.—Stuebing Truck Co., Cincinnati, Ohio.

Pneumatic Conveying—Bulletin 515 describes the use of a Dracco pneumatic conveying system for unloading, conveying and reclaiming alum.—The Dust Recovering & Conveying Co., Harvard Ave. & E. 116th St., Cleveland, Ohio.

Lighting—Catalog 47-A gives instructions and helpful illustrations for planning industrial lighting installations. Catalog 47-b describes and illustrates various types of lights.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Roller Bearing Data—A 64-page book contains descriptive and illustrative matter covering the application of Timken bearings to all kinds of automotive, transportation and industrial machinery.—The Timken Roller Bearing Co., Canton, Ohio

Worm Gear Speed Reducers—Bulletins 251, 261 and 263 describe the Horsburgh and Scott horizontal and vertical worm gear speed reducers and shows the special features in their construction.—The Horsburgh & Scott Co., Cleveland, Ohio.

Blowers—A complete description of American H. S. Fans, Class 15M, is contained in Bulletin No. 7003, together with illustrations of the different parts of the blowers, air capacity tables and drawings of the blower housings which are accompanied by tables showing the outside dimensions of the various sizes of blowers.—American Blower Co., Detroit, Mich.

Carbon Products—Announcement is is made that a new film entitled, "Behind the Pyramids" has been prepared which shows the manufacture, application, operation and care of carbon products used in the electrical industry. Arrangements for showing this may be made by writing to the Carbon Sales Division of this company.—National Carbon Co., Inc., Cleveland, Ohio.

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INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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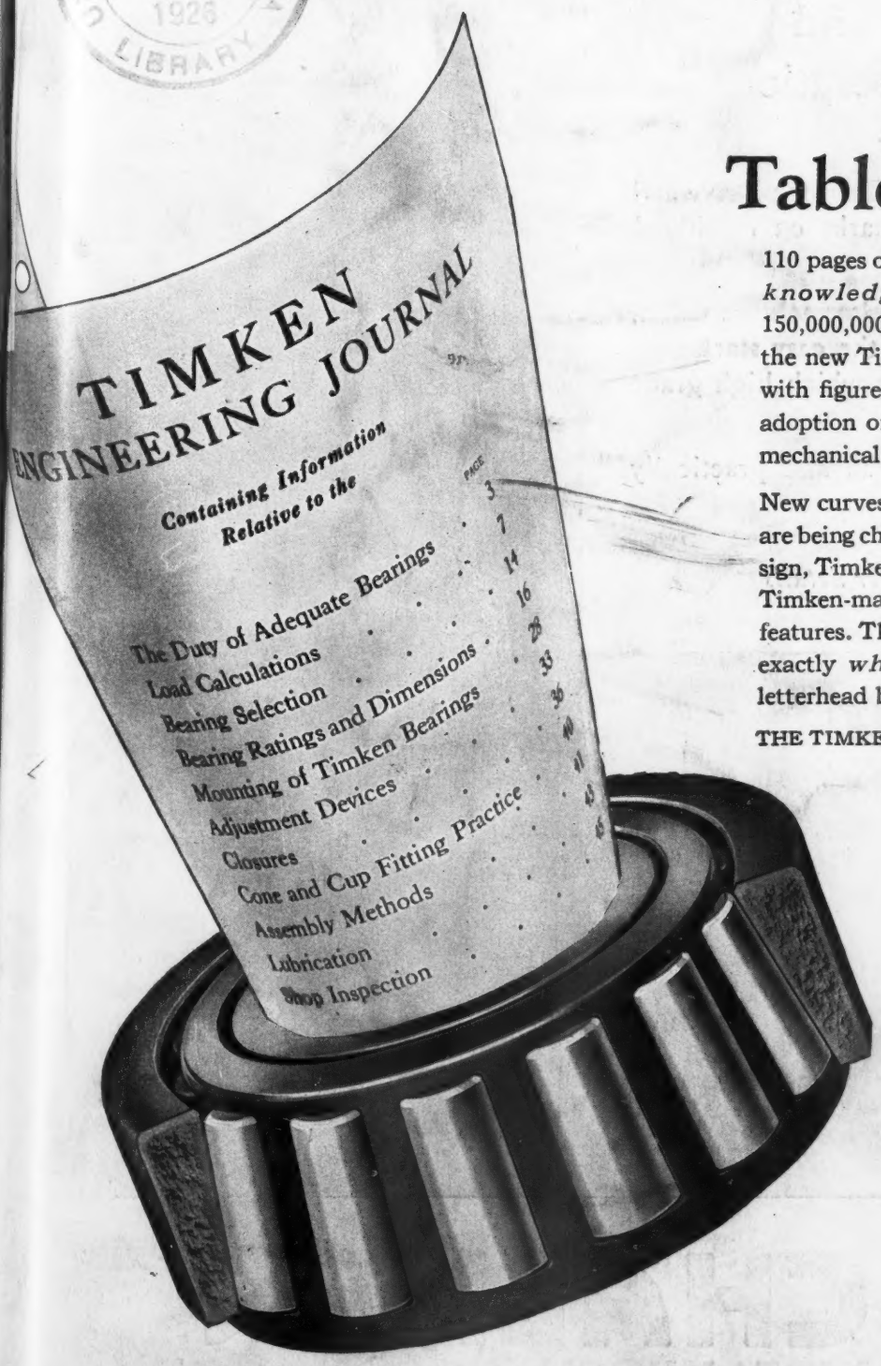

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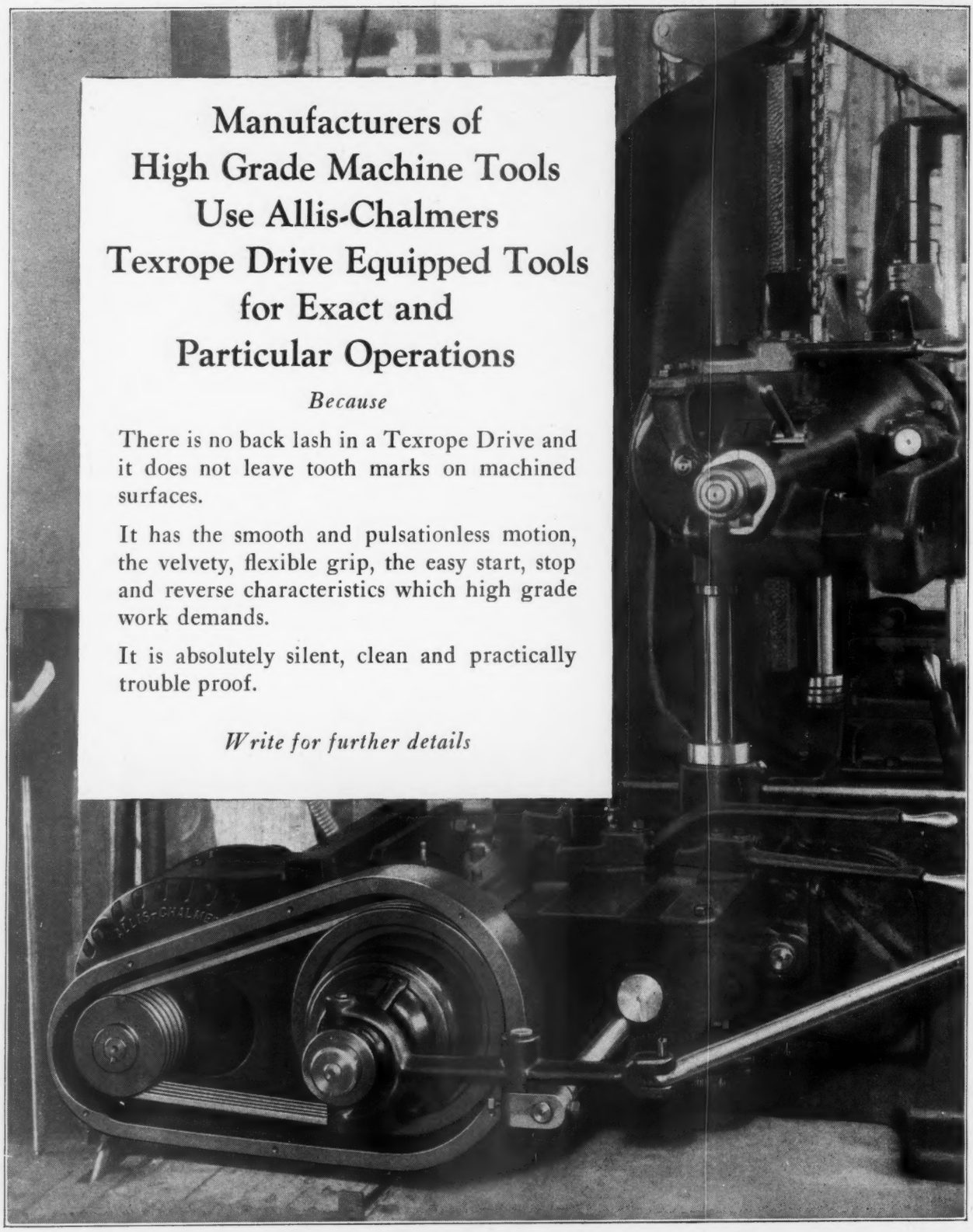

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Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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When we stop to consider the part which advertising plays in the modern life of production and trade we see that basically it is that of education. It informs its readers of the existence and nature of commodities by explaining the advantages to be derived from their use and creates for them a wider demand. It makes new thoughts, new desires, and new actions. By changing the attitude of mind it changes the material condition of the people.

Under the stimulation of advertising the country has gone from the old hand methods of production, which were so slow and laborious, with high unit costs and low wages, to our present great factory system and its mass production, with the astonishing result of low unit cost and high wages.

The pre-eminence of America in industry, which has constantly brought about a reduction of costs, has come very largely through mass production. Mass production is only possible where there is a mass demand. Mass demand has been created almost entirely through the development of advertising.

In former days goods were expected to sell themselves. Oftentimes they were carried about from door to door. Otherwise, they were displayed on the shelves and counters of the merchant. The public were supposed to know of these sources of supply and depend on themselves for their knowledge of what was to be sold.

Modern business could neither have been created nor can it be maintained on any such system. It constantly requires publicity. It is not enough that goods are made: a demand for them must also be made. It is on this foundation of enlarging production through the demands created by advertising that very much of the success of the American industrial system rests.

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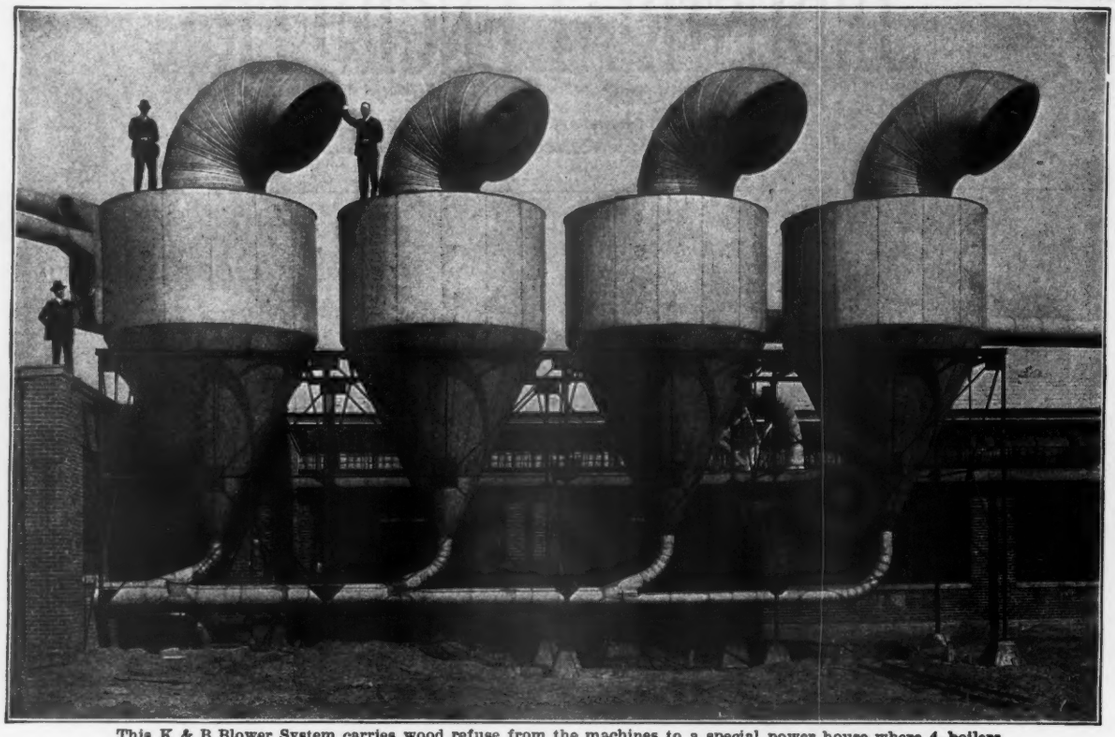
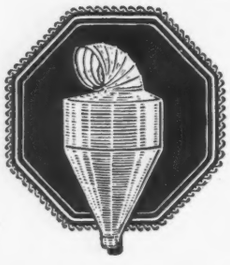
SAVING MACHINES, MOTORS, MEN AND MONEY BY BETTER DUST REMOVAL



This K & B Blower System carries wood refuse from the machines to a special power house where 4 boilers generating 600 hp. supply all heating and process steam and part of the factory power.

Better Designed Blower System Saves $9,360 Yearly



The new K & B book "Blower Systems," is a complete description of the most approved design, construction, and applications of dust-collecting equipment in wood-working and metal-working plants, glass, chemical and other industries. Send the coupon for a copy today.

Geo. F. Kroeger, Gen'l. Supt. Globe-Wernicke Division of Rand-Kardex Bureau, Inc., Cincinnati, says:

"Cutting 35,000 feet of lumber a day formerly made our mill room men look like millers, but since we put the problem up to Kirk & Blum to install a complete blower system to remove dust and refuse, many of the men wear white shirts.

"Greater cleanliness means greater efficiency, in our case it has resulted in less repairs and longer life for machines and motors, fewer accidents to men and machines, improved quality of output, lowered labor turnover, less absenteeism and better morale.

"We have had no shut-downs for repair on hundreds of feet of K & B piping, and in six years we have spent only $15.00 on patching one elbow that had the hardest wear.

"We found that the better Kirk & Blum engineering features make our present blower systems require 20% less power than our old system—which at $45 per horsepower year means a yearly saving of $3,960. This more thorough system also saves us 30%, or $2,700 a year on cleaning labor, $900 on hand trucking, and $1,80 on carting heavier refuse now put through the waste hog and blown through the pipes. This traceable money saving of $9,360 each year is nearly three times the depreciation and interest on our K & B equipment. Some managers forget that the annual power cost may easily run 50% of the first cost of a blower system, and that a cheaper system may easily mean much higher real cost than when the best designed and most economical system is installed in the first place."

A complete copy of this report will be sent to interested plant managers who will write for it on their company letterhead.

THE KIRK & BLUM MFG. CO., 2855 Spring Grove Ave., Cincinnati, O.

To The Kirk & Blum Mfg. Co., Cincinnati, O.
Please send copy of your new catalog "Kirk & Blum Blower Systems."
Firm Name .....
Individual Name .....
Address .....
City ..... State .....

Mail Coupon Today

KIRK & BLUM
Blower Systems
Collecting - Conveying - Ventilating

Chromalox Electric Heaters

FOR HEATING ISOLATED SHOPS AND OFFICES

crane cabs	drying rooms	elevators
laboratories	milk storage rooms	organ chambers
power houses	pump houses	scale rooms
storage rooms	sub-stations	watchman houses

and dozens of other places that are hard-to-heat!

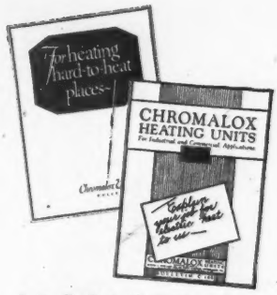
45 Sizes and Ratings. Three types. Horizontal, Vertical, Portable. 1000, 1500, 2000, 3000 watts. 110, 220, 250 volts.

Completely Assembled with 3 feet of cable, and 3-heat switch on standard conduit box. No assembly work!

Easily Installed! Simply mount on wall and connect to power line. Light and sturdy. Easily taken to the next job. Quicker than extending steam line!

Built to Last! The same type electric heaters fully approved for railway and street car service—will operate indefinitely on your heating jobs.

When writing for Bulletin C-108, send details about general construction of building, size of room or space to be heated, number of doors and windows, temperature required and voltage available. Then we can definitely tell you which size and type of electric heaters should be installed.



Left—Bulletin C-108 gives complete details about Chromalox Electric Heaters.

Right—Bulletin C-106—new edition—tells about standard Chromalox Strip, Space, Ring and Immersion Units.

Quick shipments from stock on electric heaters and heating units listed in both of these bulletins!

CHROMALOX

Mail with Your Letterhead!

[ ] Send Bulletin C-106 about Chromalox Units.
[ ] Send Bulletin C-108 about Chromalox Electric Heaters.

I.E.-12-26

We Need Electric Heat for—

Position

Signed

CHROMALOX HEATING UNITS

MANUFACTURED EXCLUSIVELY BY

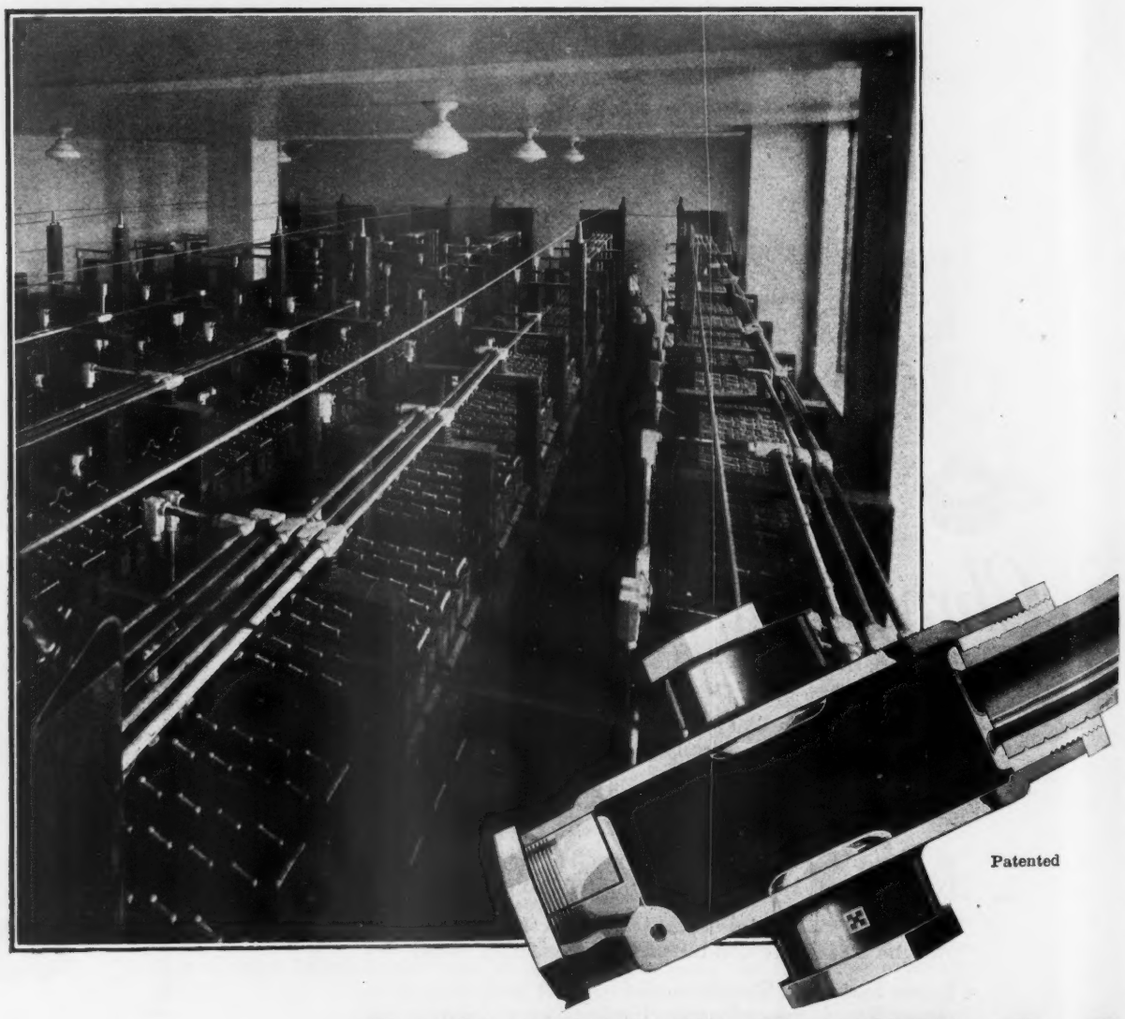
EDWIN L. WIEGAND CO., 422 FIRST AVENUE, PITTSBURGH, PA.

Sole Canadian Licensees—The Canadian Chromalox Co., Ltd., 251 Queen Street, East, Toronto, Ontario, Canada

The Railway Utility Company of Chicago is the sole distributor of Chromalox Strip Heaters for use in heating railroad and street cars in the United States and Canada

"K-O-N-D-U

WTAM Uses KONDU Threadless



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KANSAS CITY

KONDU

REGISTERED U.S.

REGISTERED

THE THREADLESS CON

Listed as Standard by

In one-half, three-quarters and one inch sizes.

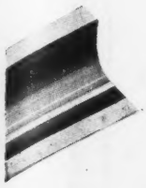
Erie Malleable Iron Co.,—Kondu Divi

Broadcasting"

Fittings In Giant New Broadcasting Battery Room

Every time you tune in on WTAM, the radio station of Willard Storage Battery Co., remember that Kondu Threadless Fittings help carry the power which brings you the music. Every one of the hundreds of conduit fittings in the great new battery room are Kondu.

Perhaps you will never face a conduit job as exacting or as intricate as this one, but whatever the job, Kondu Threadless Fittings will save a substantial percentage of the time for fitting installation. Fitting installation time usually represents the largest factor in a conduit job.



No threading is necessary—simply cut the conduit to size, ream, place in the end of the fitting, and screw down the locknut. A split, tapered bushing holds the conduit in a locked position, the ground rings in the bushing making complete conductivity.

Because threading is eliminated, it is unnecessary to rotate the conduit to lock it into the fitting, so multiple bends around obstructions may be made. Bends save fittings and the time required to install them.

Made of malleable iron—will bend, will not break—no scraping of enamel—ground rings insure perfect ground—no threads to rust—bead on bushing obviates danger of scraping insulation.

The coupon below will bring you a sample fitting, and you can see the quality and advantages yourself—send for it.

-BOX

PATENT OFFICE
IN CANADA

DUIT FITTING

Underwriters' Laboratories
Other sizes on test.

sion—Erie, Pennsylvania

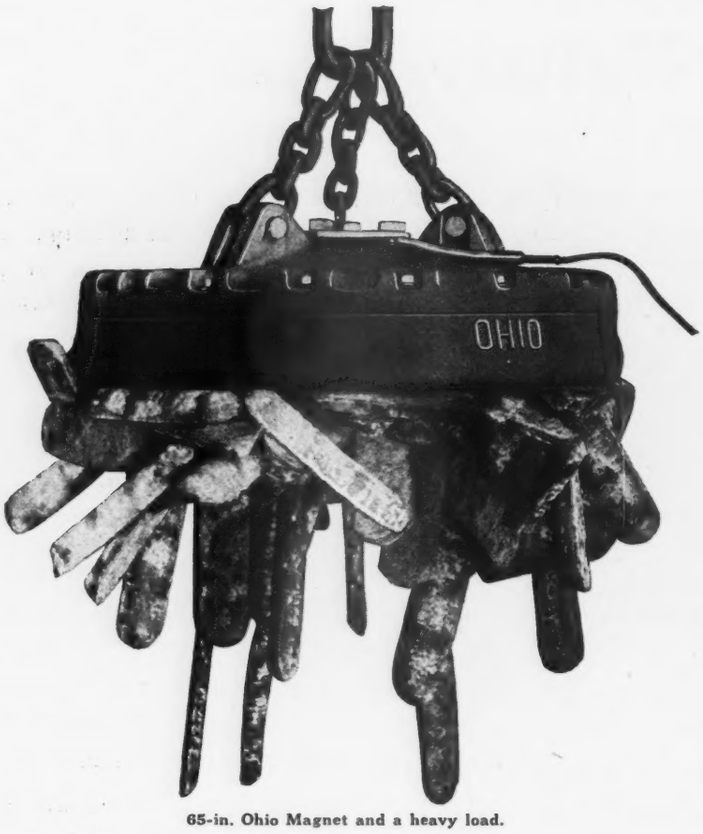
Representatives
J. G. Pomeroy Co., Los Angeles, and San Francisco, Cal.
C. R. Dederick, Portland, Oregon, and Seattle, Wash.
Fred E. Staible, Denver, Colo., and Salt Lake City, Utah.
W. A. Gibson, Dallas, Tex.
E. E. Dawes, Atlanta, Ga.

☐ Sample Fitting
☐ Catalog

KONDU DIVISION
Erie Malleable Iron Co.
ERIE, PA.

NAME.....
COMPANY.....
ADDRESS.....

OHIO Lifting Magnets



65-in. Ohio Magnet and a heavy load.

Are lighest in dead weight yet they have maximum lifting capacity and lowest cost of upkeep due to their efficient design, all asbestos insulation and the absence of bolts on the bottom or working surface.

The OHIO ELECTRIC AND CONTROLLER CO.
5910 Maurice Ave., CLEVELAND, OHIO

Which does Your own good Judgment tell you is Best—

Complicated fuses with as many parts as Joseph's coat had colors—

or

Pierce Fuses, consisting of only two parts and the link

PARTS AND THE LINK

A few simple twists of the wrist and all that there is to a Pierce Fuse lies before you—two parts and the link—simple as A, B, C.

The complete lack of complicated parts in Pierce Fuses is the reason why the two simple parts and the link can be made stronger and sturdier. That's why they stand up under repeated blows—give longer, better and safer service—and cost less to use.

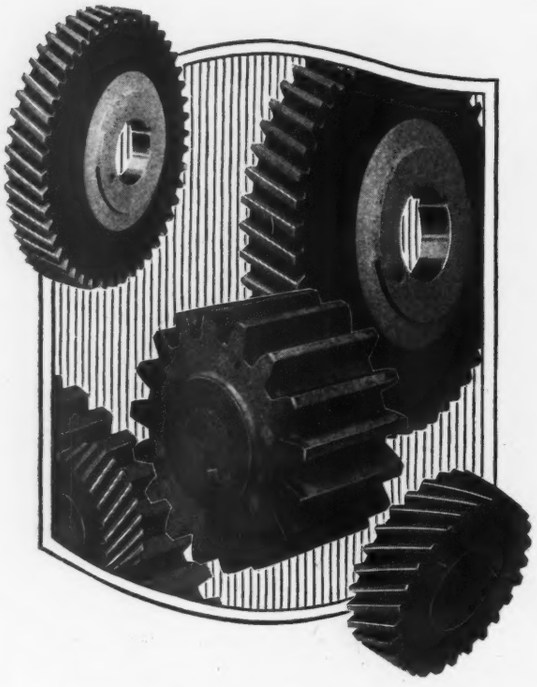
Perfect venting instantly releases all gases when blows occur. There is no confined pressure to cause dangerous explosions; no charring to damage the fuse casing. A screw driver or a thin dime, a new link and about 15 seconds, are all anyone needs to renew a Pierce Fuse.

Make a point of inspecting a Pierce Fuse the next time a salesman calls—or write for a sample. You will be fascinated with its simplicity, its strength, its ability to give long years of safe and certain performance.

Pierce RENEWABLE FUSES

PIERCE RENEWABLE FUSES, Inc. BUFFALO, N.Y.

The Demand For Formica Grows!



FORMICA steadily gains in popularity as the engineers and superintendents of American factories become more familiar with its performance.

This drift from other non-metallic gear materials is due to the fact that Formica combines remarkable durability with remarkable elasticity and silent operation. It saves the nerves of the men and increases their output. It saves the machine from shocks and increases its life.

All metal drives are becoming rarer. There is a keen appreciation of the great advantages of more silence.

Formica blanks cut from sheet can be delivered in a much shorter time than types of gears requiring special blanks built up with shrouds.

Try Formica the next time
you need a Silent Gear

FORMICA
Gear Cutters

Birmingham, Ala.
Charles C. Steward Machine Co.
Boston
Union Gear and Machine Co.
Brooklyn
Natisch Gear Works.
American Foundry and Machine Co.
Chicago
Chicago Rawhide Co.
Perfection Gear Co.
Plamandon and Co.
B. F. Gump Co.
Cincinnati
Cincinnati Gear Co.
Cleveland
F. H. Bultman and Co.
Horsburgh and Scott Co.
Stahl Gear and Machine Co.
Hoboken
Nilson-Miller Co.
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Keystone Engineering Co.
Newark, N. J.
Newark Gear Cutting Machine Co.
Philadelphia
Earl Gear and Machine Co.
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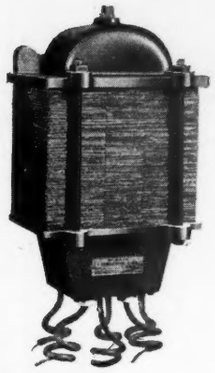
Alling Lander Company.
St. Louis
Turley Gear and Machine Co.
Worcester
Worcester Gear Company.

THE FORMICA INSULATION CO.
4640 Spring Grove Avenue ::: CINCINNATI, OHIO

FORMICA
Made from Anhydrous Bakelite Resins
SHEETS TUBES RODS

NEWARK TRANSFORMERS



This Transformer is double-wound, air cooled, single phase, 220 volt primary, 220/110 volt, 3-wire secondary.

This type is carried in stock in ½ to 10 kva. capacity.

For 440 or 550 volts primary, while not carried in stock, can be supplied promptly.

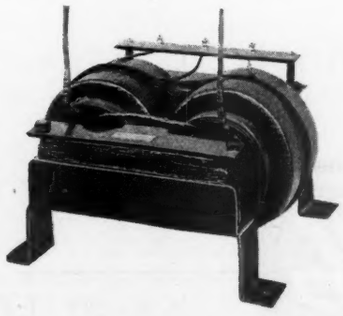
These Transformers can be used for either indoor or outdoor service.

Electric Furnace Transformers

These Transformers are supplied for Electric Furnaces and other heating devices.

The Transformer is primary-tapped. The switchboard is supplied with radial switches for controlling the secondary voltage in 5% or smaller steps.

If required, the panel can be equipped with safety devices such that when the panel door is open, the primary circuit is disconnected, thus eliminating any danger when operating the control switches.



Special Transformers

We design and build transformers to your specifications or to suit your individual requirements.

New

A convenient, compact and portable— TESTING SET

Ideally suited to the needs of manufacturing companies and industrial plants where insulation, process and other semi-high potential tests are required.

Each set is equipped to handle the testing of such units and parts as may be specified by the user, and to deliver voltages up to 20,000 or higher. The standard equipment includes compression type rheostat, Weston voltmeter, pilot lamp, circuit breaker, double-pole, double-throw primary switch for 110 or 220 volts, single-pole, single-throw secondary switch and plugs for leads.

This set is also supplied with the necessary equipment for oil testing.

Descriptive circular on request.

Thirty years' experience back of each Transformer.

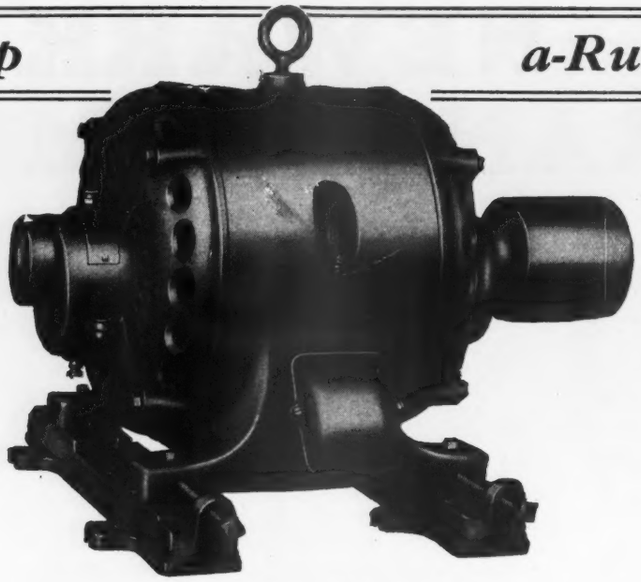
Our Engineering Department will gladly help solve your transformer problems.

NEWARK TRANSFORMER CO.
Newark, N. J.

General Sales Agents:

Porter & Ross, Inc.
30 Church St., New York City

"They Keep a-Running"



7½ Horse Power Century
Squirrel-cage Induction Polyphase Motor

Material Handling Equipment

"Keeps a-Running" With

Century

Century Squirrel-cage Induction Polyphase Motors are especially designed to meet the severe service requirements in all types of handling, elevating and conveying equipment. "They Keep a-Running" because of the following characteristics:

1 Armatures are practically indestructible. Copper conductor bars are brazed to channel-section end rings over an area equal to about six times the cross sectional area of the bars.

2 Thorough ventilation is assured by sheet steel fans mounted on each end of the armature, and—in the larger size motors—by the addition of grid ventilators as part of the armature structure.

3 Bearings are of cast phosphor bronze—the highest grade bearing material obtainable—accurately machined on all dimensions and provided with machine-cut figure-8 oil grooves.

4 Bearing housings are as nearly dust tight as it is possible to build them.

5 Shafts are of special shaft steel, ground true and then polished on all bearing surfaces.

Century Squirrel-cage Induction Polyphase Motors are built in all standard sizes from ¼ to 50 horse power.

Temperature rise not more than 40° Centigrade.

CENTURY ELECTRIC COMPANY

1806 Pine St. St. Louis, Mo.

For More Than 23 Years at St. Louis

¼ to 50 H.P.

Century MOTORS

¼ to 50 H.P.

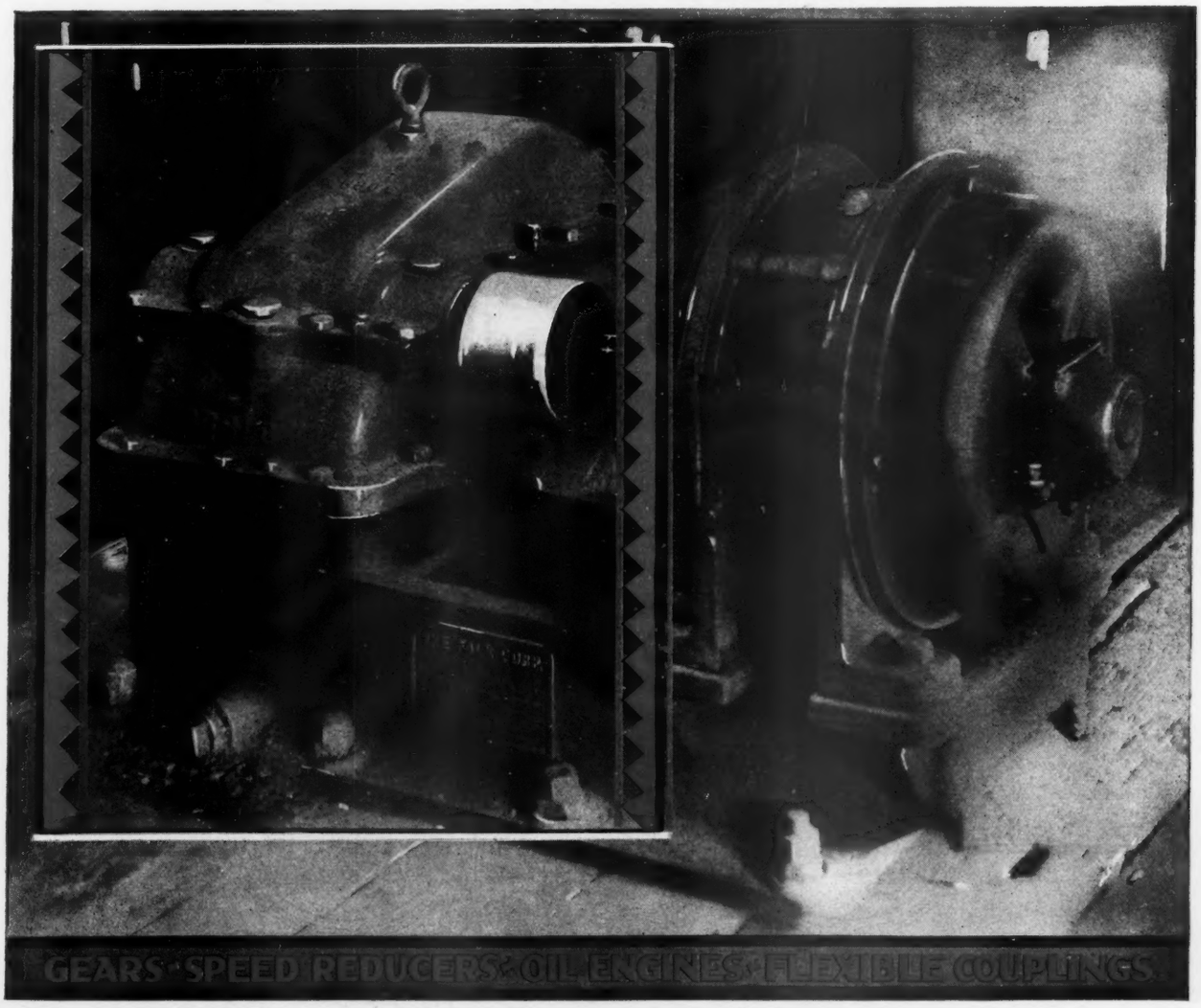
"We standardized on Falk herringbone gears throughout our plants for all the hardest drives. Altogether over 75 Falk drives, ranging from 25 to 75 h.p., are in use on saws, conveyors, fuel house drives, etc. All drives have been operating 10 to 20 hours a day since 1922 and 1923, yet we have had neither trouble nor production delays due to any failure of the Falk gear units.

"Falk gears and Falk-Bibby couplings have been entirely satisfactory, and we would not think of doing without them. We are enthusiastic about all our Falk equipment because, once installed, it is so dependable that it can be forgotten."

J. W. GATES, JR.
Crossett-Watzek-Gates, Chicago

SPEED REDUCERS

The Falk Corp., Milwaukee, Wis.



Friction and Fuel

EVEN in the most modern steam engines, seldom more than one-fifth of the heat value of the fuel is converted into power. In other words, out of every five tons of fuel used, only one ton actually produces power that turns your machinery. A considerable loss occurs in converting water to steam in the boiler. Another large loss is caused by the discharge of exhaust steam, even when efficient condensers are used. In addition to these are the losses due to radiation of heat and due to friction.

An overall efficiency of twenty per cent presupposes practically perfect lubrication. With every increase in friction, whether in the driven machinery or in the steam engine itself, the percentage of power that is available for work is decreased. More fuel must be burned to overcome this friction in order to produce the same amount of available power.

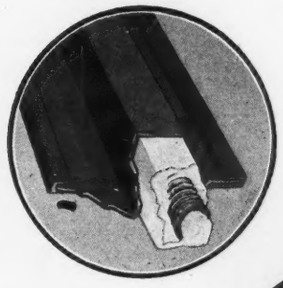
To secure the largest possible percentage of work from the fuel you burn, it is necessary that your machinery—both engines and driven machinery—be lubricated with oils and greases that exactly suit their requirements and reduce friction to a minimum.

Standard Oils and Greases

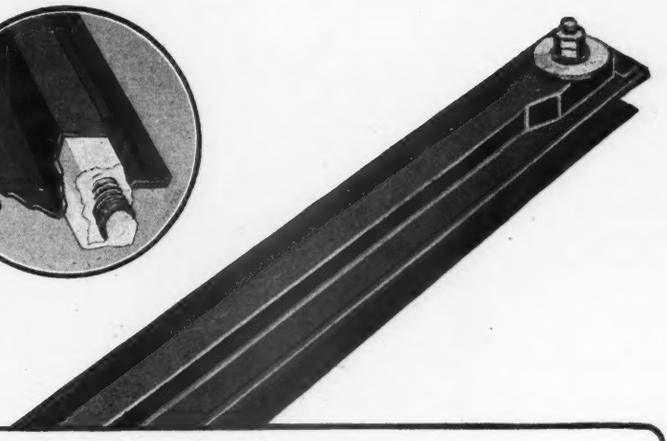
are lubricants of the highest quality, and are made in grades to suit the requirements of all machinery now used in the industrial world.

Standardize on Standard Oils and Greases and you will save fuel, reduce depreciation and repair expense, and get more power.

STANDARD OIL COMPANY
(INDIANA)
910 South Michigan Avenue Chicago, Illinois

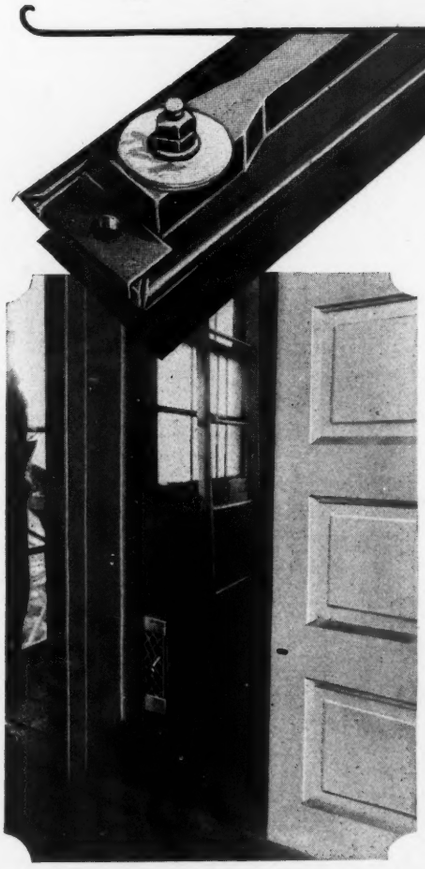


Heating element of C-H Space Heater is embedded in a new refractory material. Heating efficiency is high—radiation is quick—insulation perfect. Very durable.



Why punish men or handicap equipment by unnecessary cold?

C-H



C-H Space Heaters in Cab on Coal Bridge, Milwaukee Western Fuel Co., Milwaukee, Wis.

COLD men fumble, blunder,—often have their say about their boss. Cold machines eat power, balk,—break.

Certainly heating pays, but the question is, "How shall we do it?" Old heating methods are often too cumbersome to be practical. Sometimes they are impossible. Cutler-Hammer Space Heaters are the solution.

An electrical crane cab, for instance, or an elevator car can't be piped for steam heat. But wherever electricity is available these C-H "Heat Sticks" can be installed—in any necessary number.

Just 2 feet long, slim and compact—they are adaptable to all installation conditions. Can't be upset—they are safe.

Economical, too. Investment is negligible—efficiency is high. The heat is applied at the point needed and in the correct amount.

In all plants there are many heating jobs which these C-H Heat Sticks can do better—heating isolated rooms and buildings, maintaining proper temperatures of oils, chemicals and gases, applying heat at specific points in manufacturing processes.

Your electrical supply house has C-H Space Heaters. $2.00 each slightly less by box [10]. Order them today.

The "Dictionary of Uses" describes scores of typical installations of C-H Space Heaters. You can use many of them and they will suggest others. Write for a copy.

The CUTLER-HAMMER Mfg. Co.
Pioneer Manufacturers of Electrical Apparatus
1219 St. Paul Avenue
MILWAUKEE, WIS.

CUTLER-HAMMER

Holabird & Roche, Chicago - Architects
George A. Fuller Co., Chicago—New York
General Contractors
L. K. Comstock & Co., Chicago
Electrical Contractors

THE NEW PALMER HOUSE, *Chicago* . . . . . *Wired with*

American Steel & Wire Company's RUBBER-COVERED WIRE

We take distinct pride in the selection of our product for this building. It not only further proves the many superiorities of the wire, but is an excellent example of the standing of American Steel & Wire Company electrical wire with leading architects and contractors.

When wire specifications are most exacting for buildings of any size, large or small, American Steel & Wire Company wire may be specified and used with perfect confidence in its long satisfactory service. . . . Let us send you an indexed catalog and handbook of Electrical Wires and Cables. Estimates furnished promptly from any of our offices in all of the principal cities.

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DETROIT . . . . . Foot of First Street
CINCINNATI . . . . . Union Trust Bldg.
MINNEAPOLIS—ST. PAUL . . . . . Merchants Nat'l Bk. Bldg., St. Paul
ST. LOUIS . . . . . 506 Olive Street
KANSAS CITY . . 417 Grand Avenue
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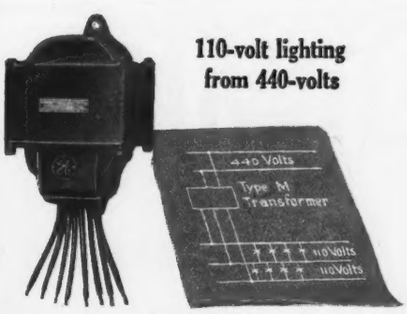
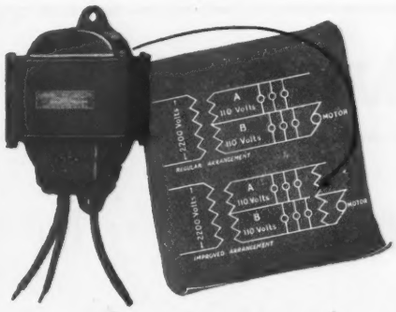
DENVER . . First National Bank Bldg.
SALT LAKE CITY . Walker Bk. Bldg.

UNITED STATES STEEL PRODUCTS COMPANY, San Francisco, Los Angeles, Portland, Seattle



110-volt lighting from 440-volts



Lamp flicker reduced

3-phase supply
2-phase operation

Power at 220
Light at 110

– and for *conduit* systems type M Transformers and Auto-transformers are built to fit *right into the line*

One of the desirable features of type-M's is the convenience with which these G-E Transformers can be used in either existing or new conduit wiring installations. For any of their various applications, the principal ones of which are illustrated above, they can be supplied so as to fit right into the line.

Carried in stock for either wiring system

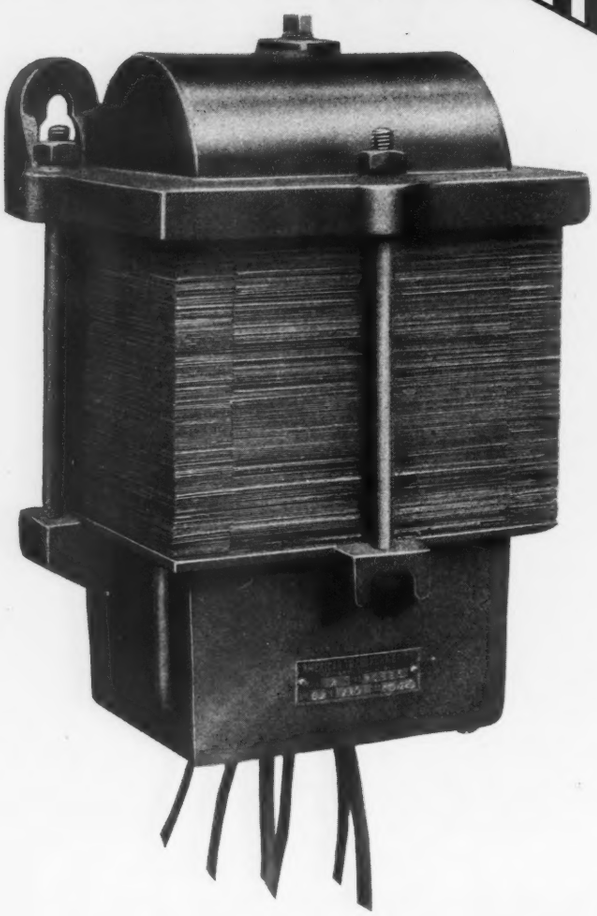
To obtain complete information covering type-M Air-Cooled Transformers—ratings, dimensions, prices—a descriptive leaflet is available, through General Electric Offices. Ask for No. 65105.

178-6

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN ALL PRINCIPAL CITIES

American Transformer



Here is real service

Feeding 110-220 volt 3 wire lighting circuits from power lines.

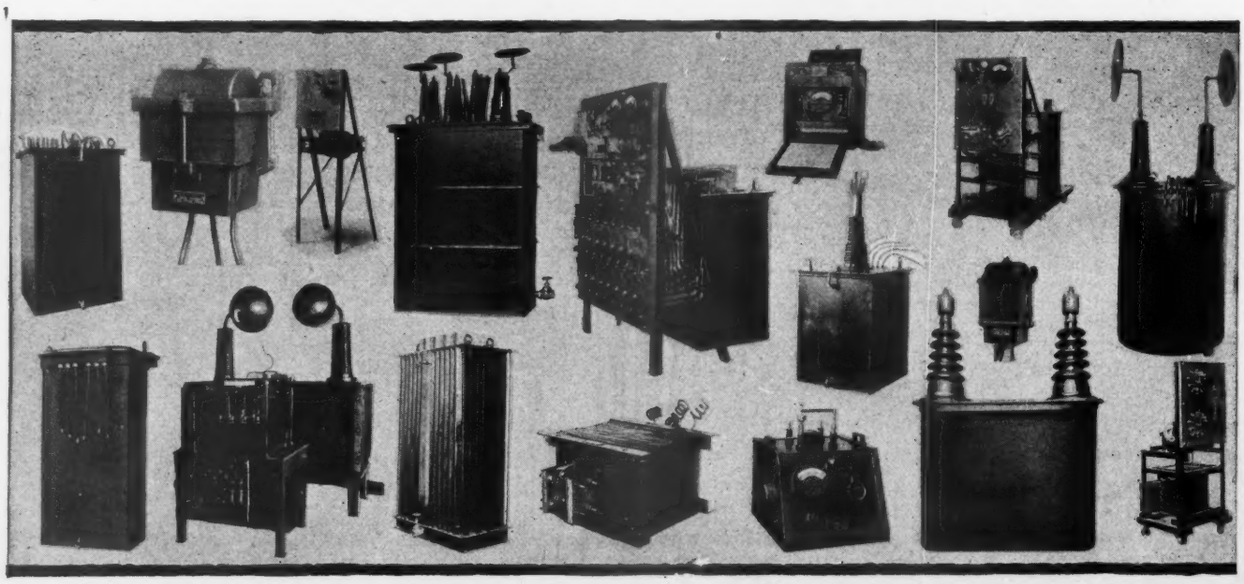
This American Transformer is of the two winding type, the primary being wound for single-phase 220 volt and the secondary for 110/220 volt. It is built in sizes 1 to 5 Kva. and is carried in stock for 220 volt 60 cycle primary. It can be wound for 440 or 550 volts for fairly quick delivery.

This transformer can be used indoor or outdoor and is exactly what the distribution superintendent and industrial plant electrical engineer require where the use of an auto transformer is forbidden.

If you have a transformer problem the services of our engineering staff are offered you without obligation

AMERICAN TRANSFORMER COMPANY
180 Emmett Street, Newark, N. J.

A Transformer to Meet Every Industrial Application



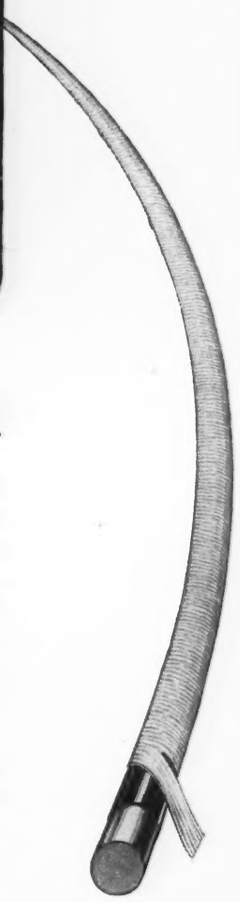
The electrical generation

WE LIVE in the electrical age. The most loved possession of the small boy is his electric train. The most faithful servants of the American woman are her electric appliances. The most economical power for man's great industrial plants is the electric power generated by central stations.

The key to the smooth, continuous functioning of every one is a strand of copper wire. Under the surface of a multitude of these toys, appliances, and huge generators lies Rome Magnet Wire.

For throughout industry you will find a growing preference, for Rome Magnet Wire, and for all Rome Wires. There is in these Rome products a desirable quality, brought by complete manufacture, supervision, and inspection in the Rome mills—from wire bar to finished copper wire.

Rome Service—ample stocks and competitive prices—are at your disposal, while an opportunity to quote on any of your wire requirements will always be welcome.

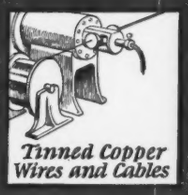


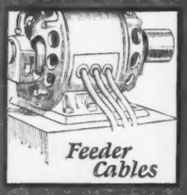
Single Cotton Enameled Magnet Wire

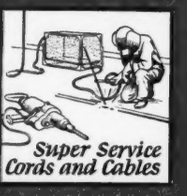
ROME WIRE COMPANY, ROME, N.Y.

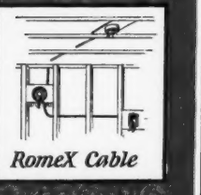
ROME WIRE

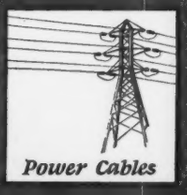
FROM WIRE BAR TO FINISHED COPPER WIRE











BECAUSE of its small outside diameter, Rome Enameled Magnet Wire is increasing in popularity every year. Particularly is this true with the manufacturers of the smaller types of electrical equipment.

Perfected by a research department that is constantly investigating and analyzing—backed by twenty years of manufacturing experience—there is small wonder that this, and all Rome wires are appreciated by their users.

If you will let us know what wires you are interested in, we will be glad to send you samples, catalogs and other information that will be of help. To those who have a particularly difficult wiring problem, we offer the advice of our Engineering Department.

ROME WIRE COMPANY

Mills and Executive Offices: ROME, N.Y.

Diamond Branch: Buffalo, N.Y.

New York—50 Church Street
Boston—1011 Little Building
Chicago—14 E. Jackson Blvd.
Detroit—25 Parsons Street
Cleveland—1200 W. 9th Street
Los Angeles—J. G. Pomeroy, Inc., 336 Azusa Street
San Francisco—J. G. Pomeroy, Inc., 960 Folsom Street

PAINT *this Way—*

Use Vorcolite

flat white, specially compounded of the finest materials for gun application. Apply with the

Vortex Equipment

loaned without cost—a large capacity, rapid working paint gun, unequaled in covering big areas. Rely on

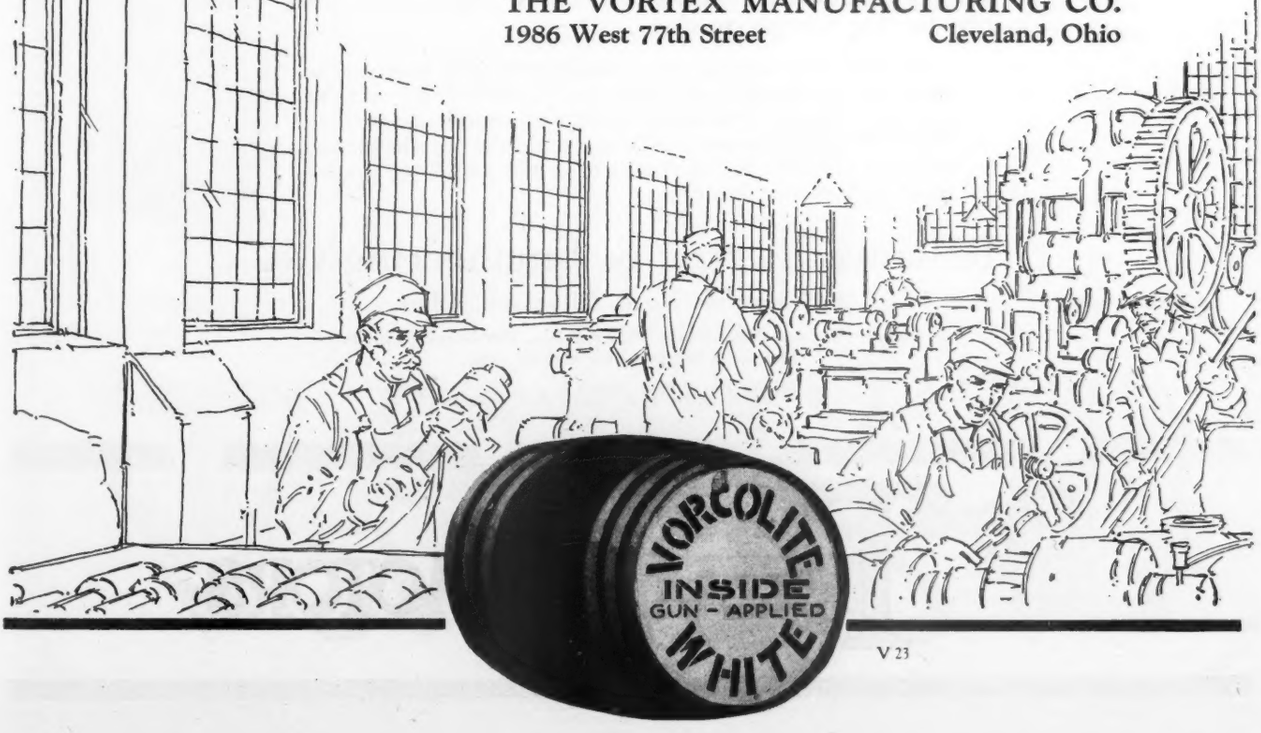
Your Handy Man

to do the work. With our paint and equipment he paints better and faster than a large squad of hand painters and needs scarcely any scaffolding.

One Application

suffices, as against two coats for any gloss paint. Flat white is better and more lasting. For additional data and estimate write to

THE VORTEX MANUFACTURING CO.
1986 West 77th Street Cleveland, Ohio



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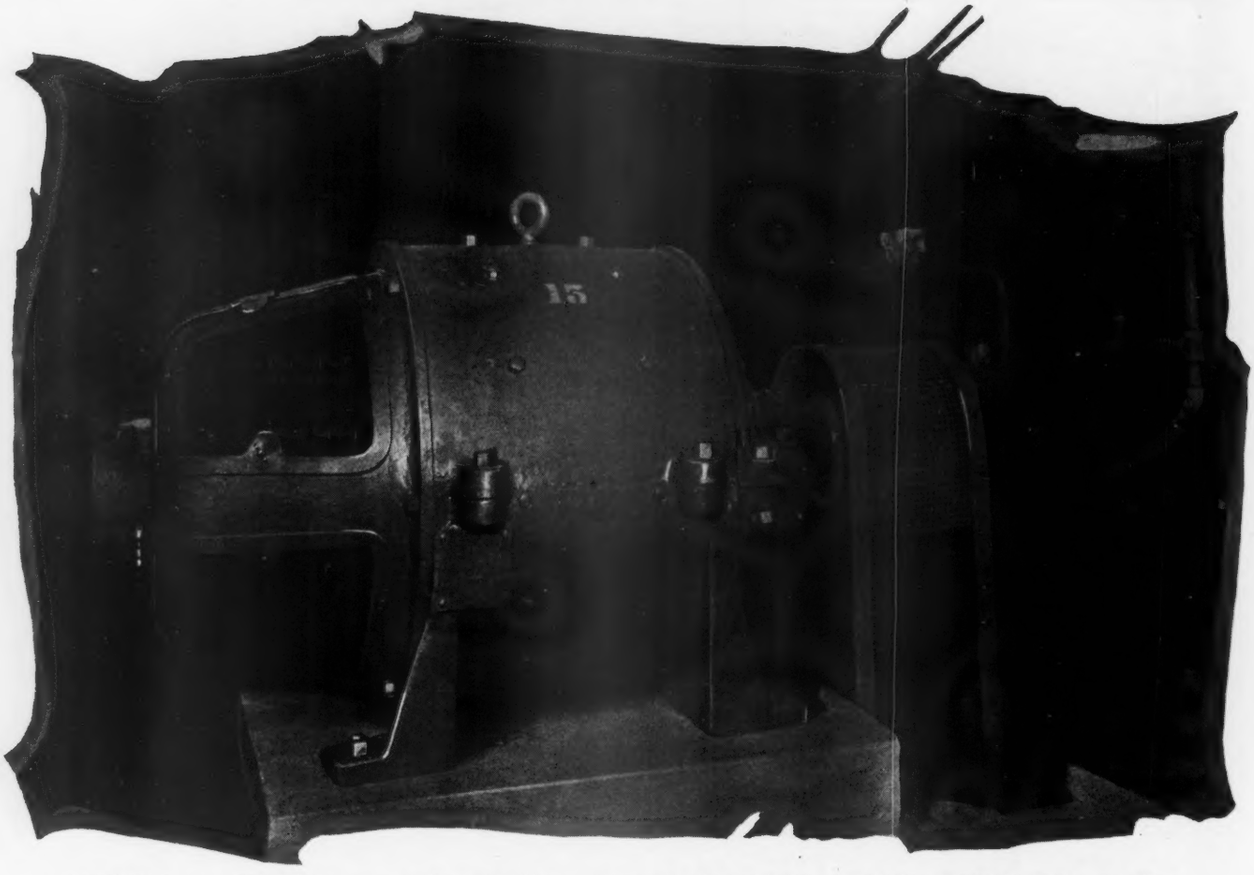


175/200 h. p., 780-800 r. p. m. Type T Heavy Duty Reliance Motor Driving Buffalo Exhaust Fan

D-C Motors up to 300 Horsepower

YOU may have thought of us as makers of motors in the smaller sizes only. We make the bigger ones, too—up to 300 h.p. 450 r.p.m. These motors have earned their title "Heavy Duty" in the steel mills, rubber mills, paper mills and other industrial plants with jobs for big motors to do.

We are daily coming into contact with jobs that can be done better and quicker with motor drive and suitable control. Many users have found our experience helpful. We shall be glad to work with you and take our chances on showing you how to get results that will justify an investment in Reliance Motors.

Reliance Electric & Engineering Co.

1051 Ivanhoe Road, Cleveland, Ohio

Branches: Boston, New York, Philadelphia, Pittsburgh, Cincinnati, Detroit, Chicago, Birmingham, Ala.

We build both D-C and A-C motors

Type T Heavy Duty RELIANCE MOTORS Direct Current

Every Industrial Plant has use for this ▽ *Safety Switch*

Concentric Knockouts
Type A contact. The contact finger is of spring copper, sweated and pinned into solid terminal block.
2 heavy springs which operate switch.
Safety handle.
Interlocking device prevents access to fuse until they are dead.
Fuse clip terminals

Type "A" heavy duty ▽ Safety Switch

Made in all capacities. For general industrial use.

There are many safety switches, but this Type "A" heavy duty ▽ Safety Switch is built, not on a price basis, but rather to give the industrial plant a switch that will meet every requirement of service, for all time.

It is very ruggedly built and made to stand up under full load or overload conditions without breakdown. It will last indefinitely, and will continually guard the safety of employees. The installation of these switches is good insurance. A few of the important features are pointed out above.

Our representative will give you more. A line to us will bring him.

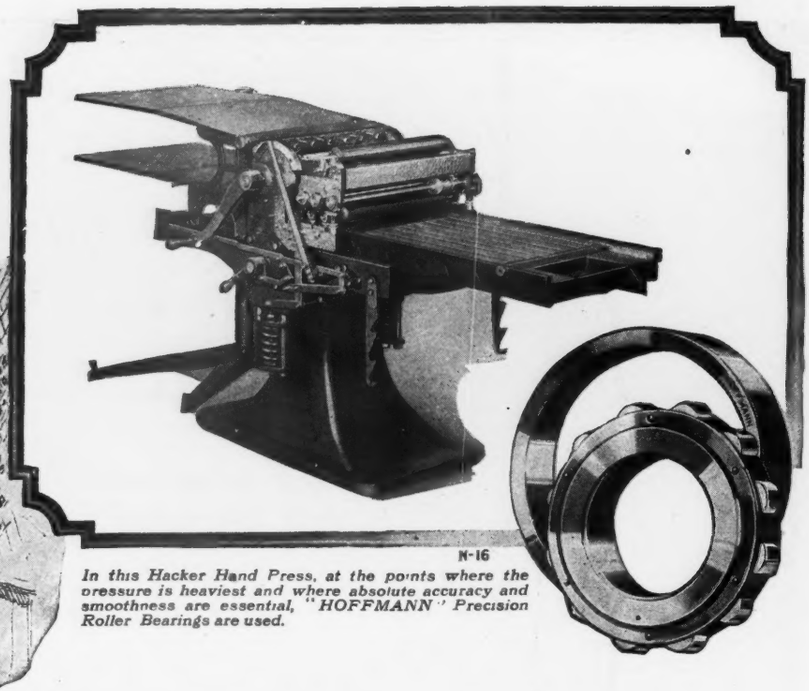
We make Safety Switches for every Industrial purpose.

Type "A" closed. Fool proof and good insurance.

TRUMBULL-VANDERPOEL ELECTRIC MFG. CO.
BANTAM, CONN.

Complete stocks are carried in eleven distributing points throughout the United States

▽ SAFETY SWITCHES



N-16

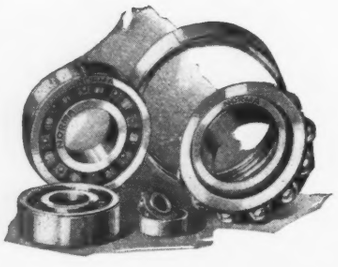
In this Hacker Hand Press, at the points where the pressure is heaviest and where absolute accuracy and smoothness are essential, "HOFFMANN" Precision Roller Bearings are used.

BUILDERS of machines which derive their value from the quality and quantity of the work they are capable of doing over long periods, fortify their product with "HOFFMANN" Precision Roller Bearings. Their unusual combination of load-ability, speed-ability and service-ability safeguards against losses in production.

Write for Catalog 904, describing the "HOFFMANN" in both standard (rigid) and self-aligning types; and for Catalog 915 giving sizes, dimensions and load ratings.

NORMA-HOFFMANN BEARINGS CORPORATION
STAMFORD, CONN. - - U. S. A.

NB-814



For the smaller powers, lighter loads, and all speeds up to 50,000 R.P.M. with the utmost in dependability.

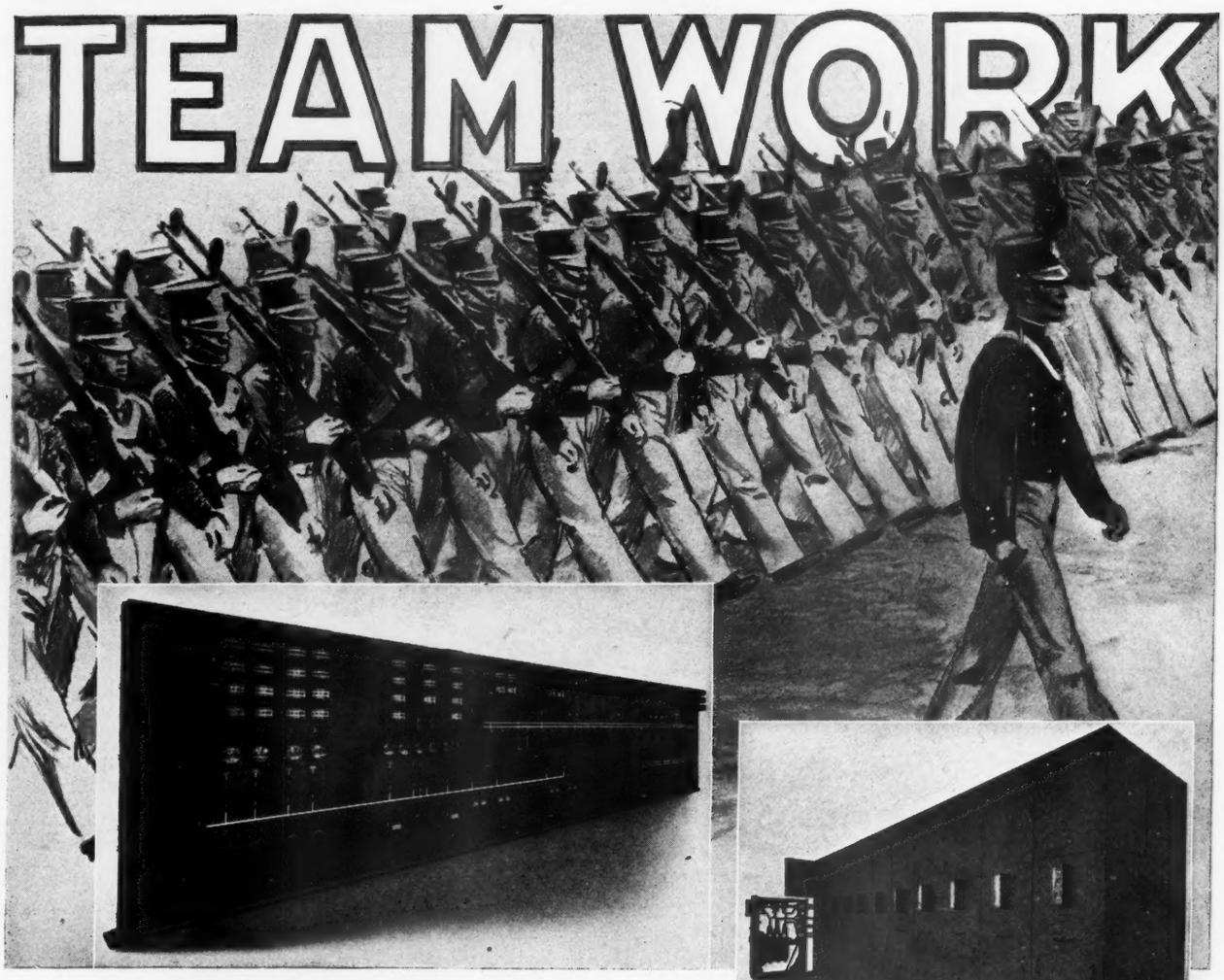
"NORMA" PRECISION BALL BEARINGS

offer machinery builders an exceptionally high factor of safety, make ing for longer life and lower cost.

Catalog 905 describes them.

"HOFFMANN" PRECISION ROLLER BEARINGS

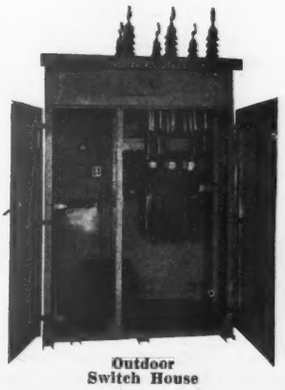
TEAM WORK



Left!—Left!—with machine-like precision every foot and arm swings forward as one. Imagine the effect that one man out of step would have on that perfect line of march! But it never happens. Each individual does his part exactly right.

Safety Enclosed Switchboard, Removable Truck Type

The same sort of teamwork from engineer to inspector must be developed to build switchboards that are one hundred per cent *right*. The Condit organization possesses the facilities to design and build the type and size of switchboards that will meet your exact requirements and the teamwork to make them as near perfection as humanly possible.



Outdoor Switch House

CONDIT ELECTRICAL MFG. CORPORATION
Manufacturers of Electrical Protective Devices
Boston, Mass.
Northern Electric Company
LIMITED
Sole Distributor for the Dominion of Canada

For safety enclosed switchboards — removable truck type — benchboards, electrical and manual controlled switchboards, get in touch with Condit.

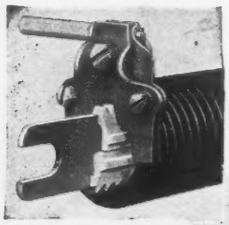
75

CONDIT

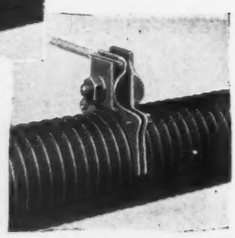
Maximum Flexibility

over widest range
of current and
space requirements

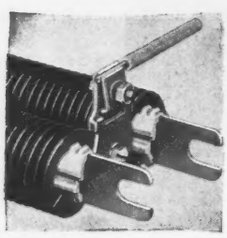
A few typical methods of mounting and interconnecting Monitor Edgewound Resistors. A single unmounted unit is shown in the foreground.



Terminal clamp used for making terminal connections and for making electrical connections between units in two or more banks.



Terminal clamp used for taking off an intermediate tap. Clamp may be placed anywhere on resistor unit



Bridging clamp used for connecting adjacent units in the same bank.

Monitor Edgewound Resistors operate perfectly either in the horizontal or vertical position. The illustration exemplifies the wide variety of arrangement available for meeting practically any current or space requirement.

Each resistor is composed of one or more spirally wound ribbon units. The resistive conductor is a nickel-copper ribbon made in different compositions and in different thicknesses to obtain various resistance values and current capacities.

The individual units may be connected in series to obtain greater resistance, or in parallel to obtain greater current capacity as conditions may necessitate. The units that are to be thus connected are mounted in one or more horizontal banks as space requirements may necessitate. These banks, or individual units in the various banks, may in turn be connected in parallel or in series to give the total resistance and current capacity desired.

Two simple forms of clamps which take a positive, firm grip on the resistive conductor, are used for connecting units or banks of units in series or parallel, for making terminal connections or for taking off taps at any desired point on the individual units.

This great flexibility is but one of the many advantages of Edgewound Resistors. Full information is given in Bulletin 10-107, a copy of which will gladly be sent on request.

Monitor Controller Company

BALTIMORE, MARYLAND

New York Chicago Buffalo Philadelphia St. Louis Birmingham
Cincinnati Boston Pittsburgh New Orleans Detroit Washington
Cleveland Los Angeles San Francisco

The Original "Just Press Button" System

Monitor Edgewound Resistor

6231-3

J-3052 Cushioned Starting Saves Belts and Bearings

THE severe jerks and strains of starting, with either a hand or automatic compensator, destroy belts and bearings. That is why Allen-Bradley J-3052 Automatic Starters prove so economical.

The use of Bradleyunit Resistors (graphite disc compression resistances) make it easy to steplessly adjust the starting torque by merely turning a single screw to start the machine without a jerk, and gradually accelerate it to full speed. The timing relay automatically switches the motor from starting to running voltage, without opening the motor circuit.

The most unskilled operator can make a perfect start with the J-3052. He simply pushes a button—the starter does the rest.

Allen-Bradley Automatic Compression Resistance Starters are adding to the life of motors, belts and machinery in all types of industrial plants. They cost less than automatic compensators. *Investigate—Mail the coupon today!*

Allen-Bradley Company, 491 Clinton St., Milwaukee, Wisconsin

If your starters can reduce our operating costs and increase production, we want to know about them. Mail your catalog today.

Name.....

Address.....

Buy Line Shafting Bearings That They May Serve YOU — *Not That You May Serve THEM*

PLAIN bearing hanger equipment requires oiling almost every day—Skayef only twice a year.

Plain bearing hanger equipment requires frequent adjustments to compensate for misalignment due to settling of buildings and other causes. Skayef is SELF-ALIGNING and requires no adjustment.

Skayef self-aligning ball bearing hanger equipment, by effecting definite savings in power, labor and lubricant costs, pays for itself in less than two years' time, depending upon operating conditions.

Write for certified copy of report of a disinterested group of engineers, covering a typical Skayef installation either in your own industry or in one closely related to it.

SKF

MARKED

Self-Aligning **HANGERS** *Ball Bearing*

1698

SKF INDUSTRIES, INCORPORATED ~ 165 BROADWAY ~ NEW YORK CITY

HERRINGBONE

Speed reducers by D. O. James Manufacturing Company—a product backed by the same reputation that has so firmly established James Spur Gear and Worm Speed Reducers with industry.

Made under a special process that allows for a continuous "V" shaped tooth with a 20° pressure and a 30° helix angle, in all ratios from 2 to 1, to 150 to 1, and from 2 to 200 H. P.

The many features of longer life, less power consumption, elimination of vibration, greater reduction in a given space, speeds and heavy duties makes these units ideal for the severe service for which they are intended.

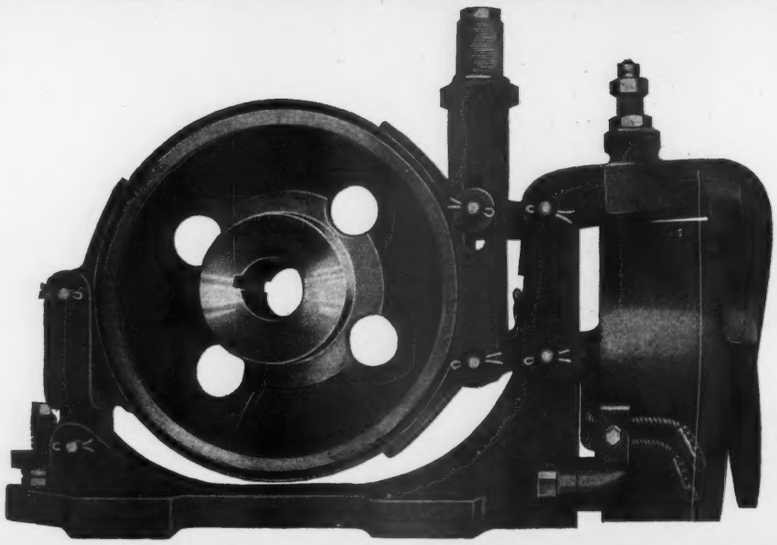
Let us tell you more about James Continuous Tooth Herringbone Speed Reducers.

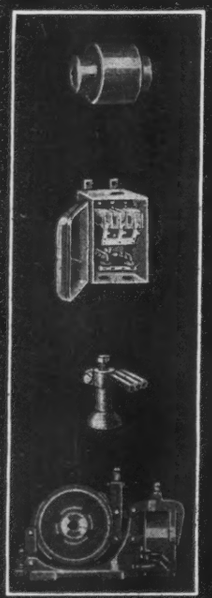
D.O.JAMES

1120 W. MONROE STREET
CHICAGO, ILL.

THE "3C" BRAKE

PROGRESS





The Clark "3C" Brake is of the split-band type. It combines band-brake efficiency with shoe-brake characteristics.

Is equally effective in either direction of rotation. Has shown exceptionally low maintenance cost.

This brake is now in use in over twenty-five different plants and has been given unqualified approval in every case.

For Further Information Write for Bulletins 102 and 102-A

THE CLARK CONTROLLER CO.

CHICAGO 53 W. JACKSON BLVD. R.E. BOCK DIST. MANAGER

DETROIT FRANCIS PALMS BLDG. L.H. ALLISON CO. DIST. MANAGER

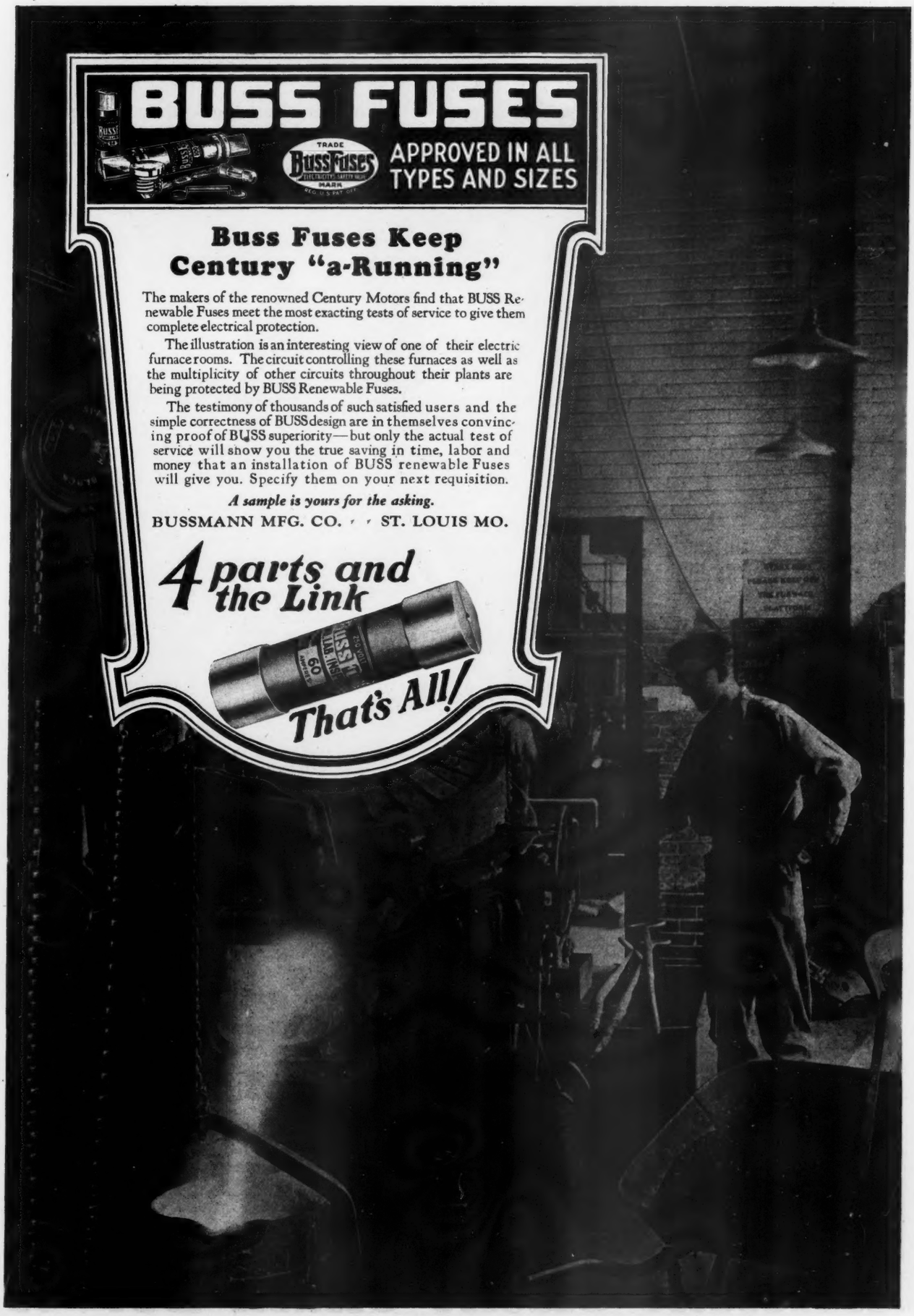
NEW YORK WOOLWORTH BLDG. K.I. CLISBY DIST. MANAGER

1146 E. 152ND ST. CLEVELAND, OHIO

PHILADELPHIA ATLANTIC BLDG. O.L. HOLCOMBE DIST. MANAGER

PITTSBURGH UNION TRUST BLDG. A.B. HOLCOMB DIST. MANAGER

BIRMINGHAM BROWN-MARX BLDG. C.P. LEIBOLD DIST. MANAGER


BUSS FUSES
APPROVED IN ALL TYPES AND SIZES
Buss Fuses Keep Century "a-Running"
The makers of the renowned Century Motors find that BUSS Renewable Fuses meet the most exacting tests of service to give them complete electrical protection.
The illustration is an interesting view of one of their electric furnace rooms. The circuit controlling these furnaces as well as the multiplicity of other circuits throughout their plants are being protected by BUSS Renewable Fuses.
The testimony of thousands of such satisfied users and the simple correctness of BUSS design are in themselves convincing proof of BUSS superiority—but only the actual test of service will show you the true saving in time, labor and money that an installation of BUSS renewable Fuses will give you. Specify them on your next requisition.
A sample is yours for the asking.
BUSSMANN MFG. CO. ST. LOUIS MO.
4 parts and the Link
That's All!

See These Liners—

They are bushings—they keep your Link-Belt Silent Chain Drives working at top efficiency even after long years of service.

Notice how the smooth hardened pin fits in between them?

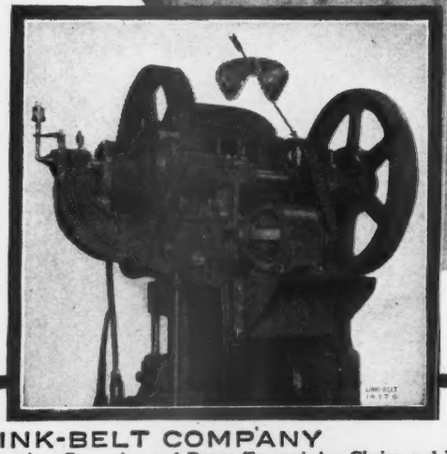
They take all the joint wear—there can be no elongation of the hole or eye of the link—this construction is truly "different".

There's the secret of durability—and incidentally smooth running, 98.2% sustained efficiency (actual test) in our Silent Chain Drives—it's in the joint construction.

Another reason why Link-Belt Silent Chain Drives, after 5, 10, 15 and even 20 years, are still in service.

Learn more about Link-Belt Silent Chain Drives and how they may be applied to machine tools. Send for a copy of Book No. 812. Also send for a copy of our Silent Chain Data Book No. 125.

2724



Drives from ½ to 10 H.P. carried in stock throughout the country.

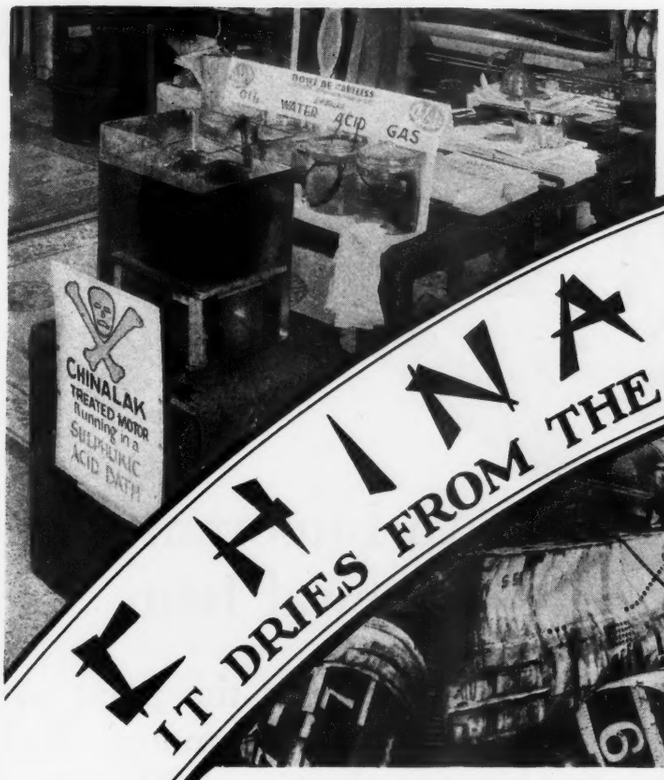
LINK-BELT COMPANY

Leading manufacturers of Elevating, Conveying and Power Transmission Chains and Machinery

PHILADELPHIA, 2045 Hunting Park Ave. CHICAGO, 300 W. Pershing Road INDIANAPOLIS, P. O. Box 85, Offices in Principal Cities

LINK-BELT

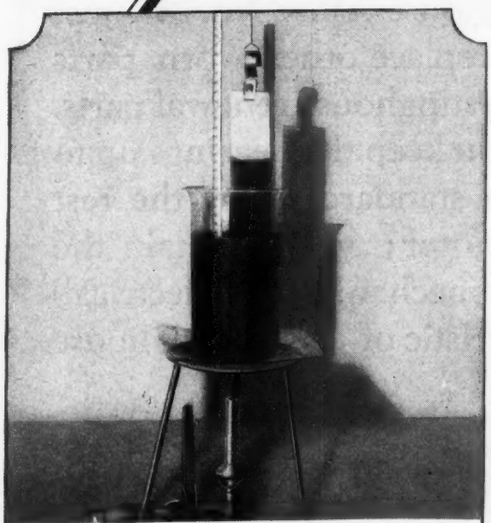
Efficient Silent Chain Drives



Chinalak treated motor operating in a Sulphuric Acid Bath. A common sight at the Annual Exposition of Iron and Steel Engineers.

CHINALAK
IT DRIES FROM THE INSIDE OUT

14 Chinalak Treated Motors—9½ Months at the Bottom of the Sea—in the S-51—Still in Working CONDITION



A.S.T.M. Method of Testing Insulating Varnish for Oilproof Qualities.

The effect of oil on a varnish is being determined by immersing specimens in oil at a temperature of 100° C. (212° F) for 48 hours and noting the effects on the varnish.

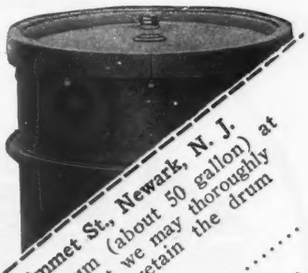
If a specimen of oil, filtered through filter paper, can be distinguished from an unfiltered sample when the two samples are held in front of a strong light, the degree of turbidity in the latter will indicate the solubility of the sample tested.

Severity of Tests Only Magnify the Extraordinary Qualities of Chinalak

In the laboratory, at expositions, and in actual service, Chinalak has been submitted to the most drastic tests. A Chinalak treated motor has been operated in a 15% Sulphuric Acid bath for more than a thousand hours. Chinalak treated parts have been cooked in lubricating oil at 212° for more than seventy-two hours. The motors taken from the ill-fated S-51 after being cleaned up were run under their own power after nine and a half months at the bottom of the sea. Records show an infinity reading between fields and ground.

Certainly there can be no question as to Chinalak's serviceability—its absolute oil and water-proof qualities, its great resistance to acids and alkalies. Furthermore Chinalak is extremely elastic, will not "liver" or "go back" and does not affect enameled wire.

If you are open to conviction you MUST use Chinalak. Avail yourself of our offer (absolutely without strings).



JOHN C. DOLPH CO.
Newark, N. J.

Agents Carrying Stock: Baker-Joslyn Company, San Francisco, Calif.; Detrick-Joslyn Company, Los Angeles, Calif.; The Fleig Corporation, Chicago, Illinois, Cleveland, Ohio.

Representatives: Mutual Foundry & Machine Co., Atlanta, Ga.; B. Pemberton, Rochester, N. Y.; Chas. E. Chapin Company, New York, N. Y.

A. Albertson, Philadelphia, Penna.; Earl B. Beach Co., Pittsburgh, Penna.; W. H. burgh, Penna.

John C. Dolph Co., 168 Emmet St., Newark, N. J.
Please send me a removable head drum (about 50 gallon) at $1.35 a gallon F. O. B. my shop, so that we may thoroughly test Chinalak. I understand I may retain the drum without charge.

Signed .....

per .....

Address .....

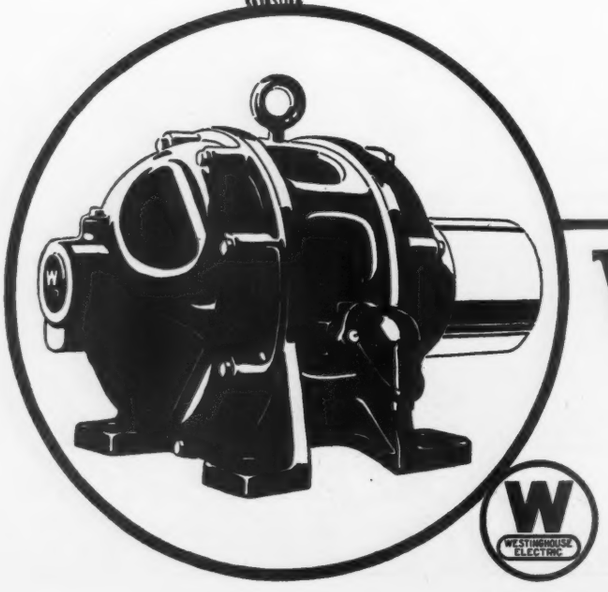
This order is subject to Dolph's broad guarantee that if Black Baking Chinalak does not prove satisfactory, it may be returned and amount charged will be refunded immediately.

BABBITT—

An Important Renewal Item

THE bearing is the point of greatest wear in a motor. Rebabbitt worn bearings in Westinghouse industrial motors with Westinghouse Alloy No. 25—just as you replace other worn parts with Westinghouse renewal parts. Then, you keep the bearings up to the high standard set by the rest of the motor; you maintain the ***balance*** (mechanical and electrical) characteristic of all Westinghouse motors.

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries

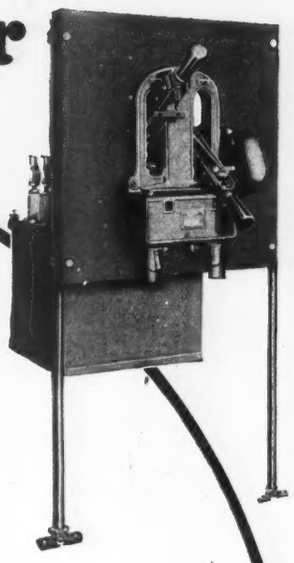


Westinghouse

X91001

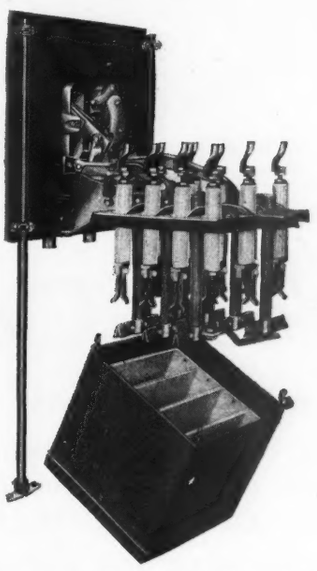
Alloy No. 25
(Lead Base Babbitt)

A New Motor-Starting Oil Circuit Breaker



Type MF

Capacity 1,000 hp. at 2,500 volts. Interrupting capacities 1,000 to 7,200 amperes at rated voltages.

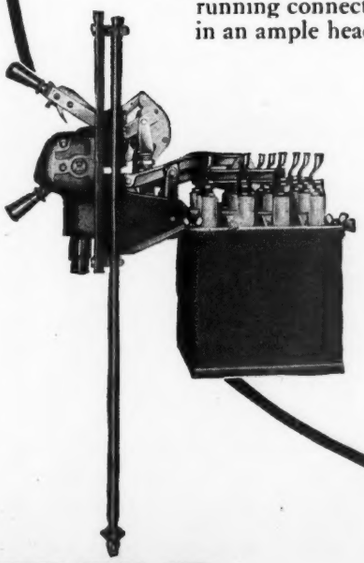


MANUALLY operated, for starting, in connection with auto-transformers, three-phase induction motors and self-starting synchronous motors.

A careless, or ignorant operator cannot throw the wrong switch handle when starting the motor. A mechanical sequence-starting interlock prevents throwing the breaker to the running position without first going through the starting position.

Some other distinctive features are:

One tank contains all starting and running connections, immersed in an ample head of oil.



A highly efficient form of wedge and finger-type contacts is used. The fingers are flexibly mounted, therefore self-aligning, exerting high contact pressure by means of a separate stiff-steel spring.

The safety of the apparatus is assured by inverse time limit, automatic overload current-transformer trip coils, and by under-voltage release mechanism, which opens the breaker when the voltage fails.

Send for Leaflet 20292; it gives a full description of the MF breaker.

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries

W WESTINGHOUSE ELECTRIC

Westinghouse

X90164

Keep Yours Clean

SYSTEMATIC cleaning of lamps and reflectors is an easy matter, with Westinghouse automatic cut-out hangers. A pull on the rope and the fixture comes down. The cleaner is absolutely safe, because the lamp is cut off from the current supply. After the fixture is clean, it is pulled up and automatically locked in position. A simple operation and a safe one.

For cleaning or lamp renewal, the installation of these hangers is a measure for safety, economy and efficiency in your plant. Write our nearest district office for complete information.

Westinghouse Electric & Manufacturing Company
Merchandising Department South Bend, Indiana

Westinghouse

X90183

Spark Test. Visible check on steel composition performed by an expert.

Projecting lantern for physical research and examination of specimens.

Spring Type Bearing Testing Machine, for testing endurance under load.

THE enduring quality and precision of New Departure Ball Bearings is assured by the most exacting laboratorial checks and tests known to metallurgical science.

The production of New Departure Ball Bearings has doubled within the last five years. The endurance life of New Departure Ball Bearings has increased 600 per cent. in the same length of time.

Our staff of engineers is at your disposal for the solution of your bearing problems. A request puts you under no obligation.

New Departure Quality Ball Bearings

Engineering data in the form of bulletins will be furnished you together with a convenient binder provided you can make advantageous use of them.

THE NEW DEPARTURE MANUFACTURING COMPANY

Chicago *Bristol, Connecticut* Detroit

Chemical Laboratory. Research for both qualitative and quantitative analysis.

Amsler Precision Compression Machine. Capable of measuring resistance to crushing forces of from 150 pounds to 200,000 pounds.

Physical Testing Laboratory. General research and testing for quality of product.

506

MAINTENANCE SERVICE, REPAIR PARTS, TOOLS AND SUPPLIES

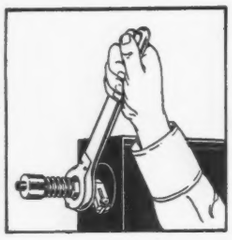
In the maintenance departments of every industrial works and in every commercial electrical repair shop the range of the work that *can be done* and the dollar-savings that *are possible* depend on
(1) The ability and experience of the maintenance man.
(2) Adequate hand and bench tools and shop equipment.
(3) A well-balanced stock of spare units, parts, wiring supplies and raw material used in repair work.

Here then is a directory to the needs of the maintenance man under items (2) and (3) that he can use when he must have things in a hurry on an emergency job and when ordering for stock to meet his regular maintenance requirements.

GUARANTEED *To Save Money!*

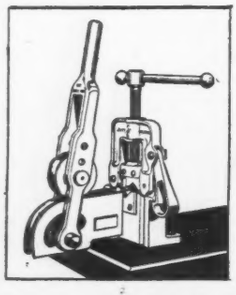
ALL JIFFY TOOLS

are guaranteed to prove satisfactory or your money refunded promptly. Order any tool on approval.



"JIFFY" Adjustable CUTTER

Cuts holes in steel boxes, switchboard panels, etc., any diameter ¾ in. to 6 in., quickly, easily and inexpensively. A time- and labor-saver necessary in every electrical department.



"JIFFY" PIPE BENDER VISE

Makes perfect bends, quickly, easily and accurately without kinking, flattening or splitting the pipe. Bends either downwards or sidewise. Eliminates in many cases costly fittings. Insures absolute accuracy.

Bends either ½- or ¾-in. conduit. Strongly built, it will serve also as an ordinary pipe vise for pipe up to 2 in. Pays for itself in Time and Money Saved. A Real Labor Saver.

Order It on Approval.

PAUL W. KOCH & CO.
33 S. Wells St., CHICAGO
Write for Complete Catalog

"CARENCO"

BRUSHES

Operate without spark or noise.
These characteristics are so noticeable, they eliminate all costly identification marks.
After thorough tests "Carenco" Brushes are adopted as a Standard Brush equipment by many of the biggest users.

Let us send you our new catalog and data sheet. Prove the value of "Carenco" Brushes to yourself!

CARBON-ENGINEERING-CO.
Milwaukee, Wis.

Maintenance and Repair

will get special attention in

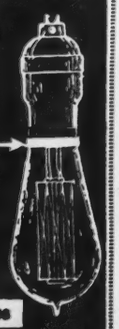
February, 1927, *issue*

LOCK YOUR LAMPS

WITH **REN-LOCKS** FIT STANDARD BULBS AND SOCKETS

ONLY TWO PARTS

A COILED SPRING and A GROOVED RING



We Sell Direct—Write for Samples

Ren Mfg. Co. 371 Main St. Winchester, Mass.

FIGURE IT OUT

Flower Brush Holders are designed and built by brush holder specialists to meet the needs of a specific job. They're simple—they're rugged—and they're made only from the finest virgin metals. Naturally they last longer, are more reliable, and parctically eliminate "flashover" risks.

Quotations gladly given on any type

FLOWER
BRUSH HOLDERS

D. B. FLOWER
1217 Spring Garden Street, Philadelphia

Manufacturers of Brush Holders for Motors, Rotary Converters, Generators and Dynamos

NO Spark Carbon Brushes

are Self Lubricating They last longer and serve better than ordinary Brushes. Give them just one trial.

Calebaugh Self-Lubricating Carbon Co.
1503 Columbus Ave.
Philadelphia, Pa.

This Silver Strand (Reg.) now marks the shunts of all National Pyramid Brushes

ON ANY brush-equipped electrical machine, look at the brush shunts. Look for the Silver Strand. It is the visible identifying mark on all National Pyramid Brushes—your guarantee of satisfactory brush performance.

All shunts of National Pyramid Brushes now bear this Silver Strand as an identifying mark, visible to the most casual glance. The familiar letters NCC, the three pyramids and the grade number will still be found on the brush itself for your guidance in purchasing and installing. When the brush is in service, the Silver Strand in the shunt is a visual sign to all that here is a National Pyramid Brush, supremely suited for the work for which it is designed.

Thousands of brushes are now in use bearing this shunt, which has the same conductivity as the former unmarked shunts. The Silver Strand is a mark that indicates, but does not affect, the perfection of performance you have learned to expect from National Pyramid Brushes. Look for the Silver Strand.

National Pyramid Brushes

Manufactured and guaranteed by

NATIONAL CARBON COMPANY, INC.

Carbon Sales Division

Cleveland, Ohio San Francisco, Cal.

Canadian National Carbon Co., Limited, Toronto, Ontario

Emergency Service Plants

CHICAGO, ILL. 551 West Monroe St. *Phone:* State 6092

PITTSBURGH, PA. 7th Floor, Arrott Power Bldg. No. 3, Barker Place *Phone:* Atlantic 3570

NEW YORK, N. Y. 357 West 36th St. *Phone:* Lackawanna 8153

BIRMINGHAM, ALA. 1824 Ninth Ave., N. *Phone:* Main 4016

Meals must

Westinghouse Motors

be Balanced

—so must MOTORS

MEAT, mashed potatoes and white bread, with cakes, cheese and coffee:—sounds like a pretty good layout, doesn't it?

A submarine crew tried such a diet and was forced into port after eight month's cruising with some of their men at the point of death.

Similarly, unbalanced design—improper proportioning of the factors listed here—may hurry a motor into the service shop. A motor's life and service depend on the skill and experience with which the manufacturer balances all the factors to one another and to the work for which the motor is designed

For instance, efficiency: Beyond a certain point in the design of every motor, added efficiency can be obtained only at too great sacrifice of other qualities. Compare a Westinghouse alternating-current motor of 89 per cent efficiency, with a rival motor rated at 90 per cent. On the face of things this comparison is unfavorable to Westinghouse. Look at power factor, however, and you find that to gain 1 per cent more efficiency the rival motor has reduced power factor to 85 per cent, while that of Westinghouse is 88 per cent. Thus in terms of *power bills* the motor with a closer balance between power factor and efficiency is by far the better motor.

A motor is balanced when the following factors are properly proportioned to one another and to the job which the motor has to do:

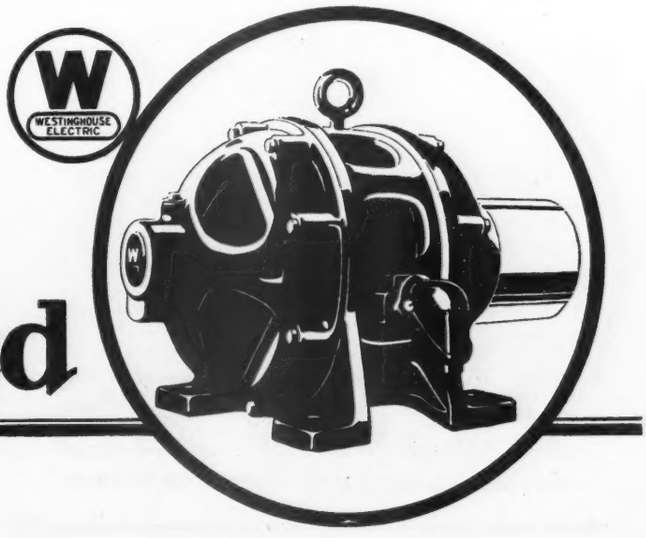
Electrical	Mechanical
1. Temperature	8. Air gap
2. Torques	9. Bearings
3. Efficiency	10. Shaft
4. Power Factor (in alternating-current motors).	11. Steel
5. Speed characteristics	12. Assembly
6. Insulation	13. Rotating smoothness
7. Commutation (in direct-current motors)	

To get true value in a motor look at *all* these factors, not merely at one or two.

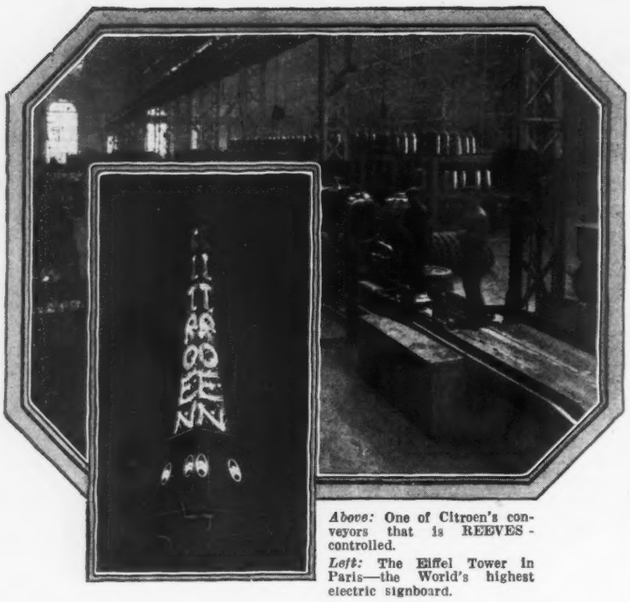
In Westinghouse Motors each factor has been weighted after years of experience extending into every industry and dating from the dawn of the motorizing idea. A truly balanced design for every purpose is the result.

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of the United States and Foreign Countries

X88782



are Balanced



Above: One of Citroen's conveyors that is REEVES-controlled.

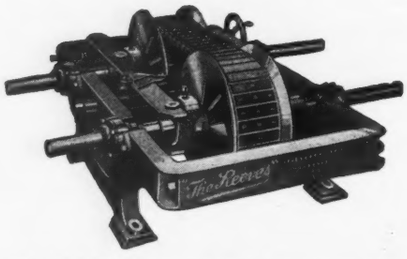
Left: The Eiffel Tower in Paris—the World's highest electric signboard.

André Citroën Knows the Value of Speed Flexibility!

ANDRÉ Citroën has modeled after the best "Detroit" methods in the production of his automobile. His plants in France, Italy, England and Belgium have a yearly capacity of 235,000 cars—the greatest production schedule of any European manufacturer.

Citroën regulates the speed of his conveyors with the device used by Buick, Cadillac, Hudson, Chrysler, Chevrolet, Packard and other leading American automobile manufacturers. He uses 110 Reeves Transmissions. In *your* industry, on *your* production machines and conveyors, there is a very definite need for speed flexibility. Send for Catalog E-66 for complete information.

REEVES PULLEY COMPANY
Established 1887
Columbus, Indiana



THE REEVES Transmission represents the *only* method which gives you *complete* speed flexibility. It does not give just steps in speed—but *any* speed between fastest and slowest, even to the smallest fraction of a revolution. It is simple, inexpensive, compact. Easy to install and simple to operate. You can get *any* speed at *any* time on *any* machine that is REEVES-equipped.

REEVES
Variable Speed Transmission

NITCHI JATHA

The nitchi jatha is the native deep diver.

He constructs for himself an ingenious telescope to spy out the wonders of the ocean bed.

It's simply a large tin can with a sheet of glass on one side.

It works—so he's satisfied.

Now let us change the scene to a plant equipped with misfit carbon brushes.

Enter the Morganite engineer to help the operators improve commutation.

He's told through the din of the chattering brushes that they work—so they're satisfied.

The answer to which is a long story which you can get by calling in one of the representatives below:

Morganite Brush Co., Inc.

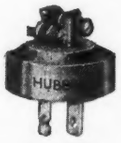
Main Office and Factory
519 West 38th St., New York

DISTRICT ENGINEERS AND AGENTS

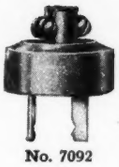
Pittsburgh, Electrical Engineering & Mfg. Co., 909 Penn Ave.
Cincinnati, Electrical Engineering & Mfg. Co., 607 Mercantile Library Building.
Cleveland, Electrical Engineering & Mfg. Co., 422 Union Building.
Baltimore, O. T. Hall, Sales Engineer, 437-A Equitable Building.
Revere, Mass., J. F. Drummey, 75 Pleasant Street.
Los Angeles, Special Service Sales Co., 502 Delta Building.
San Francisco, Special Service Sales Co., 222 Underwood Building, 545 Market Street.
Toronto, Can., Railway & Power Engineering Corp., Ltd., 101 Eastern Ave.
Montreal, Can., Railway & Power Engineering Corp., Ltd., 326 Craig St., West.
Winnipeg, Can., Railway & Power Engineering Corp., Ltd., P. O. Box 325.

No. 7056
2-wire
Tandem Blades
10 Amp., 250 V.

No. 7057
2-wire
Parallel Blades
10 Amp., 250 V.



No. 7059
2-wire
Parallel Blades
Polarized
10 Amp., 250 V.

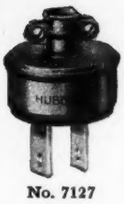


No. 7092
2-wire
Polarized
10 Amp., 250 V.

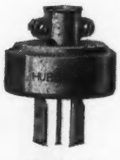
No. 7055
3-wire
Polarized
10 Amp. 250 V

No. 7058
2-wire
Polarized
20 Amp., 250 V.

No. 7089
3-wire
Polarized
20 Amp., 250 V.



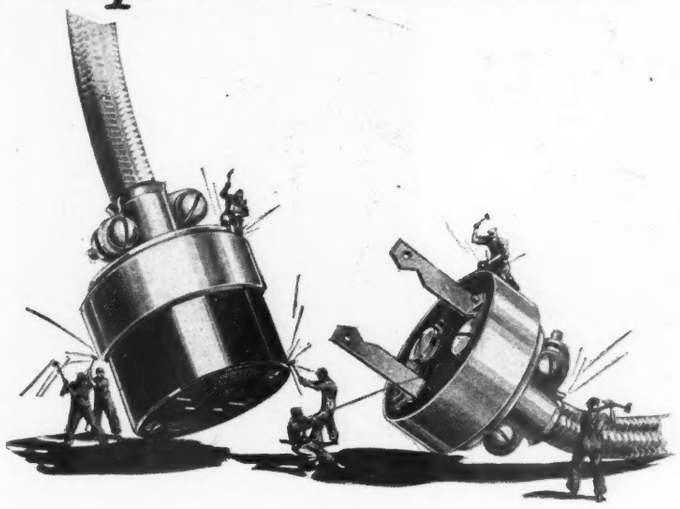
No. 7127
2-wire
Polarized
30 Amp., 250 V.



No. 7113
3-wire
Polarized
30 Amp., 250 V.

Cord HUBBELL Grip

Caps and Connectors



TOUGH—from head to toe!

Hard Knocks—gruelling shop service
—is what these devices thrive on

The connector bodies of these Hubbell "Cord Grip" Devices are made of strong black composition. They withstand the hardest kind of service and abuse.

Caps of composition are *completely* armored by a heavy, "all-over" shield of steel—galvanized to prevent corrosion. The contact blades, because they are made of heavy gauge metal and are firmly anchored, stay in alignment and don't get "wobbly."

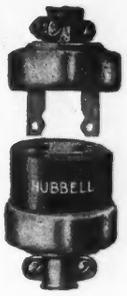
Ask your electrical supply house to show you samples.

The New "Twist-Lock" Locking Connector

See this new Hubbell Connector, illustrated at the right—Catalog No. 7100. Plug the cap into this connector—turn—and the two are securely *locked* together. A twist of the wrist—and they are unlocked.

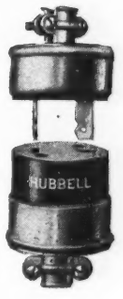
The locking feature of this Hubbell Connector provides an extra and very effective safeguard against accidental disconnection. It is of distinct advantage in industrial plants and other places, particularly where service is unusually severe or where connectors are subjected to considerable vibration.

HARVEY HUBBELL INC.
ELECTRICAL SPECIALTIES
BRIDGEPORT, CONNECTICUT, U.S.A.
NEW YORK, N.Y. CHICAGO, ILL.



No. 7083
2-wire
Double Te-slots
10 Amp., 250 V.

No. 7090
2-wire
Polarized
10 Amp., 250 V.



No 7085
2-wire
Polarized
20 Amp., 250 V.

No. 7081
3-wire
Polarized
10 Amp., 250 V.

No. 7087
3-wire
Polarized
20 Amp., 250 V.

No. 7100
2-wire
"Twist-Lock,"
Locking Type,
10 Amp., 250 V.

And ~~~ in the field of AC Manual Control G-E offers

General Electric builds control of exceptional design, construction, and performance for every motor application. Write for the Industrial Control Catalog, GEA-257. It contains the complete story together with much valuable information on correct control applications.

CR1034, 2200 V. starting compensator for two- and three-phase induction motors. Dead-front, panel type; high interrupting capacity; time delay undervoltage protection; thermal overload protection.

CR1034 starting compensator (550 V. and less) for two- and three-phase induction motors. Undervoltage protection (with time delay if desired); thermal overload protection.

GENERAL

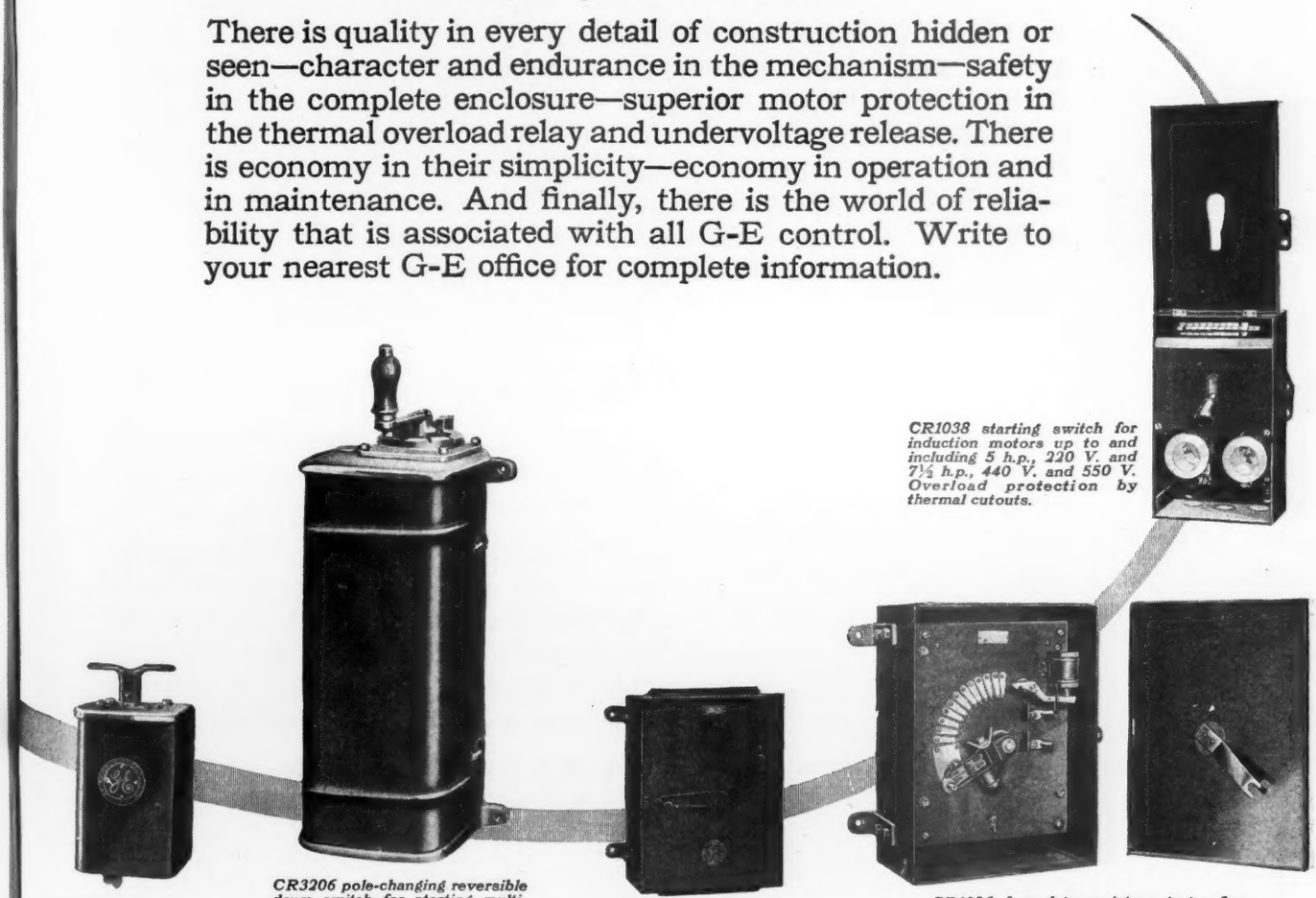
GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

WHERE frequent starting, heavy duty, remote control, or automatic acceleration is demanded, you will want G-E magnetic control.

There are, however, in your plants, motors which are started occasionally; their duty is simple; their operation requires little attention. For these, General Electric offers a complete line of manual starters.

Here are shown the most popular of the a-c. manual motor starters. These are typical of the complete line.

There is quality in every detail of construction hidden or seen—character and endurance in the mechanism—safety in the complete enclosure—superior motor protection in the thermal overload relay and undervoltage release. There is economy in their simplicity—economy in operation and in maintenance. And finally, there is the world of reliability that is associated with all G-E control. Write to your nearest G-E office for complete information.



CR1038 starting switch for induction motors up to and including 5 h.p., 220 V. and 7½ h.p., 440 V. and 550 V. Overload protection by thermal cutouts.

CR3900 reversing drum switch for two- and three-phase squirrel cage induction motors. Furnished with T-handle, knob handle, rope lever, or shipper rod lever.

CR3206 pole-changing reversible drum switch for starting multi-speed induction motors. Made for both constant horsepower and constant torque motors.

CR1028 face-plate resistor starter for secondary control of slip ring induction motors. Used with CR-7006 magnetic primary switches it provides undervoltage and overload protection.

CR1026 face-plate resistor starter for single phase induction motors. It provides undervoltage protection.

301-8

ELECTRIC

SALES OFFICES IN PRINCIPAL CITIES

Pop Decides Not to Fire the Sweeper

'Here, Lad—

fire that sweeper in the lower plant—he's too careless! Last night he ran his rubbish truck against a motor and broke a foot off it—so we lose that machine's production until they get a new motor on the job."

"No, Pop—

you can't buy common sense in a sweeper, but you'd at least *expect* it in a motor maker.

There's always something sideswiping motors—and yet your gang of stiff-back motor assemblers stick to cast-iron feet. If they themselves didn't have clay feet they would weld drop-forged feet to a steel frame—just as in the Linc-Weld Motor.

Then your sweeper could do calisthenics with a sixteen-pound sledge and he couldn't 'drop' a motor."

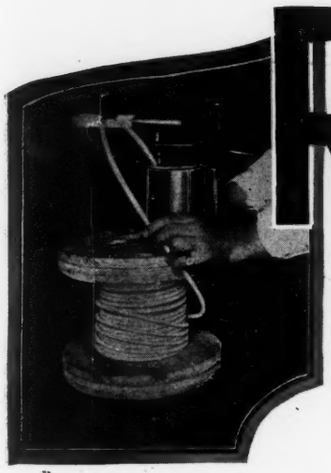
See Page 7 of the Motor Book. Better get yourself a copy from Dept. 5-12

The Lincoln Electric Company, Cleveland, Ohio

MA-2

"Linc-Weld"

LINCOLN MOTOR



ROCKBESTOS
— the asbestos covered wire

For General and Unusual Service

Rockbestos Magnet Wire is usually found in all types of motors that are subjected to extreme heat conditions or to overloads that would break down ordinary magnet wire.

Rockbestos insulation cannot be improved and has long been the standard for asbestos covered wire and cable. The motor here illustrated is one of the Crocker-Wheeler heavy duty type, operating a Bloom Shear. Overloading or unusual heat conditions will not effect the operation of the motor, because of the protection afforded by Rockbestos insulation. This is only one instance of the daily service Rockbestos magnet and other wires are giving.

How about your spare motors? Are you rewinding them with Rockbestos?

It's good insurance against shut down.

ROCKBESTOS Research and Advisory Service

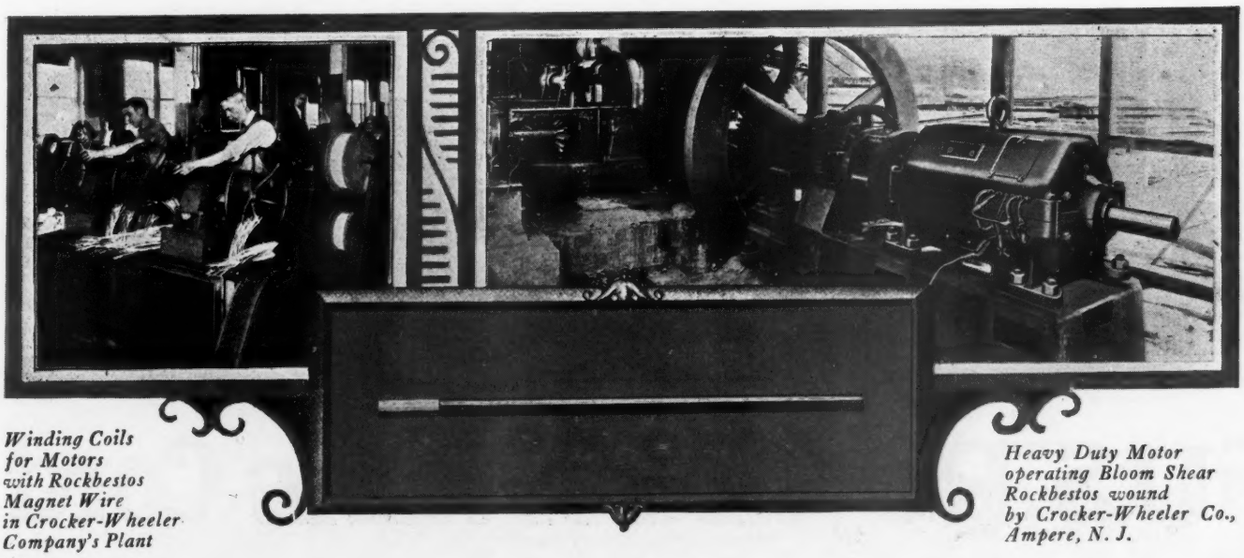
There are unlimited uses for asbestos covered wire and cable in industrial plants, and Rockbestos will give better service and greater protection against accident, because they are so well made. Our engineers and a complete research laboratory are ready to help plant engineers in selecting the proper wire for the job.

Magnet wire for motors
Switchboard wire
Fixture wire
Cables

ROCKBESTOS PRODUCTS CORPORATION

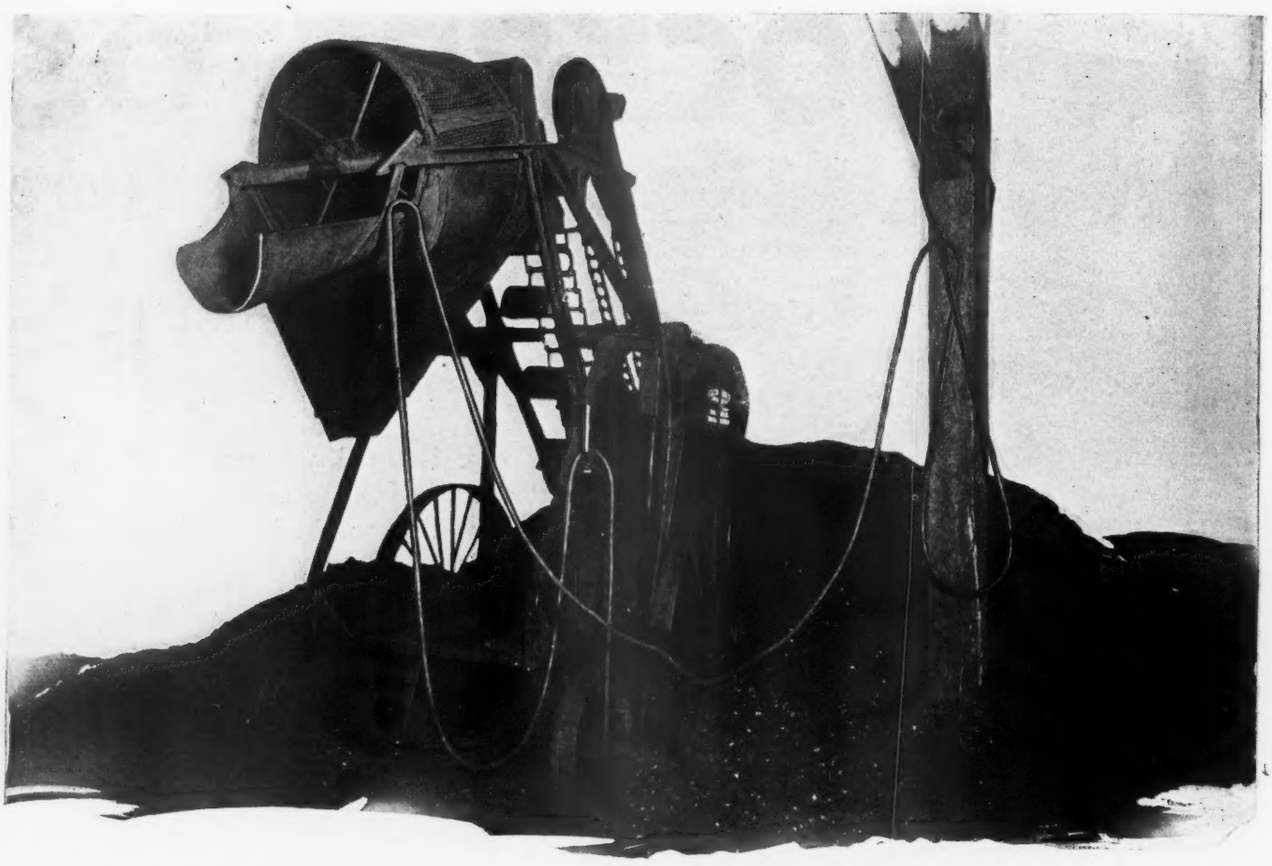
5942 Grand Central Term. Bldg., New York — NEW HAVEN, CONN. — Madison Term. Bldg., Chicago

A copy of our Blue Book on wire will be sent cheerfully.



Winding Coils for Motors with Rockbestos Magnet Wire in Crocker-Wheeler Company's Plant

Heavy Duty Motor operating Bloom Shear Rockbestos wound by Crocker-Wheeler Co., Ampere, N. J.



"We have used "U.S." Royal Portable Cord for several years—and highly recommend it"

Biddeford and Saco Coal Company, Biddeford, Maine

Industrial plants throughout the country have had the same success with "U. S." Royal Portable Cord as the Biddeford and Saco Coal Company. Mr. Staples, Manager of this concern further writes:

"We can't imagine where you could place a cord to be more abused than in our plant. It has withstood this abuse—and we highly recommend it."

This is another instance where "U.S." Royal Portable Cord is paying its way. The sturdy, tough, resilient rubber cover protects the conductor while defying the hardest kind of use and abuse.

There is a type of "U.S." Royal Portable Cord for every industrial need. Let us send you a sample to test under your own conditions.

Trade Mark

United States Rubber Company

1790 Broadway New York City

Branches in All Industrial Centers

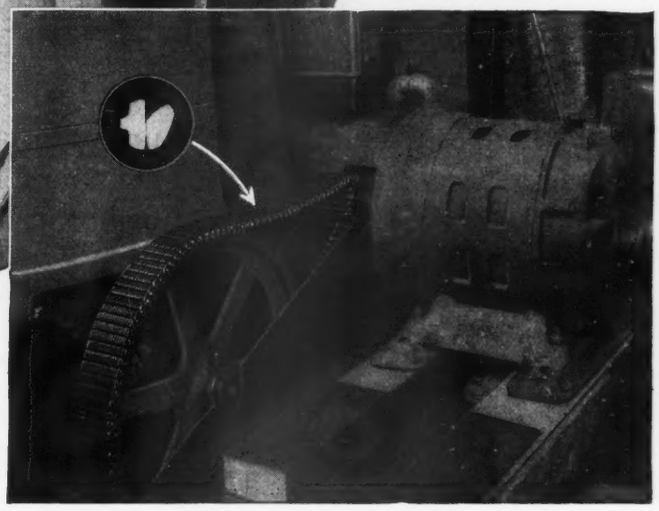
Complete Stocks Carried in the Following Cities:

Atlanta	Chicago	Detroit	New Orleans	Portland, Ore.	Seattle
Baltimore	Cincinnati	Houston	New York	Rochester	Spokane
Birmingham	Cleveland	Indianapolis	Omaha	Sacramento	St. Louis
Boston	Columbus	Kansas City	Philadelphia	Salt Lake City	Syracuse
Buffalo	Denver	Los Angeles	Pittsburgh	San Francisco	Toledo
		Minneapolis			

"U.S." Royal Portable Cord

REG. U.S. PAT. OFF.

20 H.P. Morse Silent Chain Drive from motor to sand mixer, American Radiator Co., Buffalo, N. Y. Driver, 725 r.p.m.; Driven, 112 r.p.m., 36 inch centers.



MORSE DRIVES and AMERICAN RADIATORS

IDEAL BOILERS and American Radiators economically provide heat and make many homes warm and comfortable. Back of this well-known line of heat producers, there must necessarily be efficient manufacturing processes and dependable equipment.

At the plant of the American Radiator Co., Morse Silent Chain Drives contribute to dependable and low-cost production by keeping machines in continuous operation. Their sustained efficiency of 98.6%, their flexibility and positive action—these and numerous other features are helping to solve production problems for many nationally known concerns.

Over 6,000,000 H.P. in use, one tenth to 5,000 H.P., 6,000 to 250 r.p.m. and slower. The nearest Morse Transmission Engineer is always available.

MORSE CHAIN CO., ITHACA, N. Y., U. S. A.

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BUFFALO, N. Y.....Ellicott Square Bldg.
CHARLOTTE, N. C..404 Commercial Bank Bldg.
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1240

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Electric Vibrating Horns

Type No. 3

Megaphone

Two Way

Three Way

Schwarze Industrial Horns are capable of producing an audible sound above the hum of machinery in the noisiest plants. As fire alarms, superintendent and general call signals they are unexcelled. Current supply can be high or low voltage A.C. or D.C. Further particulars, prices, catalogs, etc., gladly sent on request.

Manufactured by

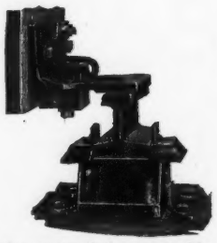
Schwarze Electric Co.
Adrian, Mich., U. S. A.

Keystone Contact Rail Material—

Contact rail shoe assembly for under-running contact.

Designed and manufactured to give long service and constant contact on cranes, conveyors and other electric industrial hoisting and hauling systems.

Our engineers will co-operate in the selection and installation of various types to meet your requirements. ESSCO Catalog sent on request.



Contact rail shoe assembly for over-running contact.

ELECTRIC SERVICE SUPPLIES CO.

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MAGNET WIRE

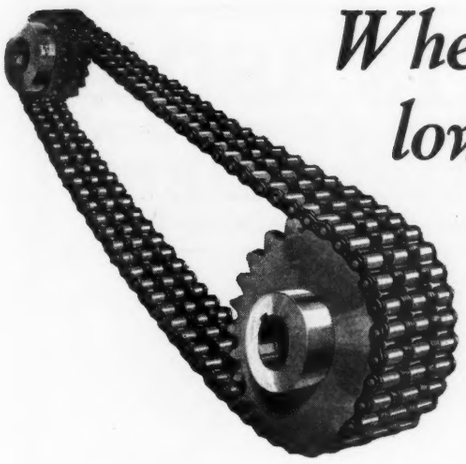
MARING PROCESS

THE MARING PROCESS insures constant current-carrier service through the combination of sound basic principles with exclusive, proven methods of manufacture.

ENAMELED, COTTON AND SILK COVERED

MARING WIRE COMPANY

Factory and General Offices
MUSKEGON, MICHIGAN



When you think of the ease and low-cost of its maintenance

OCCASIONAL inspection and a little oil—that's all the attention a Diamond Roller Chain ordinarily requires—and it keeps your drive on "roller bearing" efficiency through years of dependable, *positive* transmission.

High speeds or heavy loads do not effect its operation and, if a link should have to be replaced, [due to some unusual accident] only a few minutes are required and the cost is negligible.

Add this essential feature of economical and easy maintenance to the advantages listed at the left—and being proven today in thousands of applications—and you will realize that Diamond Roller Chains really *cost less* in the end than belts that slip, or gears that wear, waste power, and grow noisy. They are the ideal link between driving and driven part, both in first cost and maintenance.

—and the rest of these features:

EFFICIENT ON SPEEDS AS HIGH AS 3600 R.P.M.

Rolling in contact with the sprockets—Lowered friction that results in more than 98% efficiency—a power transmission equal to that of silent chains.

Positive drive maintains a consistent speed ratio—None of the "slip" present with belts, none of the lost power and noise due to the sliding friction of worn gear teeth.

Unaffected by weather conditions and less affected by adverse operating conditions than other drives.

Compact—Occupies less space for transmission of a given amount of power.

Rolling Surfaces ◇ *Prevent Wear*

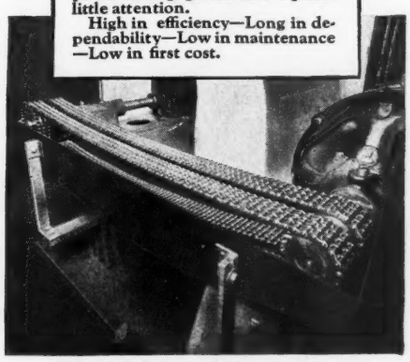
DIAMOND CHAIN

ROLLING ~ AT POINTS OF CONTACT

Flexible—Efficient on long or short centers, high speed ratios. Adaptable to a wide variety of drives.

Easy to repair, links quickly replaced at negligible cost. Requires little attention.

High in efficiency—Long in dependability—Low in maintenance—Low in first cost.



Double, Three-Strand Diamond High Speed Roller Chain on a motor-to-blower drive. Diamond Chain gives more than 98% efficiency of power transmission at speeds as high as 3600 r.p.m.

TRADE ◇ MARK

Look for the Diamond on the Link

Makers of High Grade Chains since 1890

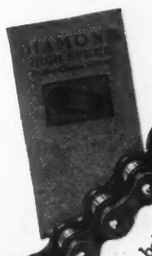
Practically no maintenance!—

Letters reporting the performance of Diamond Roller Chain in all fields of industry and on drives of every description are finding their way into our files daily. The comment which is most indicative of Diamond Chain economy and that occurs with the greatest frequency is—"Practically no maintenance has been required."

The same design and manufacturing achievement which has raised Diamond Roller Chain out of the slow-speed transmission class to the point where it operates smoothly, quietly and efficiently at speeds as high as any other type of chain is responsible for its long-wearing dependability with a minimum of maintenance expense.

—A real saving on every drive that mounts up rapidly when the entire plant operation is considered—

Send for this interesting booklet.



TEAR ALONG THE ROLLERS

You may send a copy of your booklet to the address below.

Name..... I. E.

Firm Name.....

Address.....

City..... State.....

The DIAMOND CHAIN & MFG. CO. **INDIANAPOLIS, INDIANA**

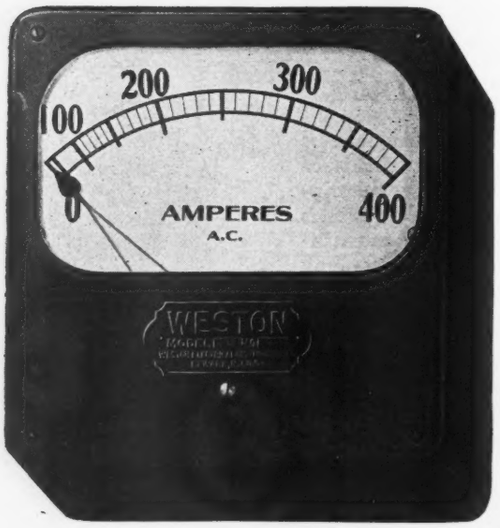
For

Engineering Economy

WESTON

Rectangulars

IN THE last analysis Weston instruments mean economy of thought, time, expense. The Weston line of rectangular instruments for large power boards makes it possible for the engineer to design and lay out his installations to be efficient, compact and easily adaptable to growing loads or changing conditions. ¶ Knowing the facts he cannot compare any other electrical measuring device favorably with the well-known Weston quality, adaptability or performance. ¶ Weston rectangulars economize space on the board, and in addition, this group of instruments gives great scale legibility, standardization of mounting and unusually simple and pleasing appearance. To exactly know their advantages, write a note to our engineering staff giving specifications. ¶ These instruments are provided as A. C. Ammeters, Voltmeters and Wattmeters, Reactive Component Meters, Frequency Meters, Power Factor Meters, Triplex Ammeters and D. C. Voltmeters and Ammeters.



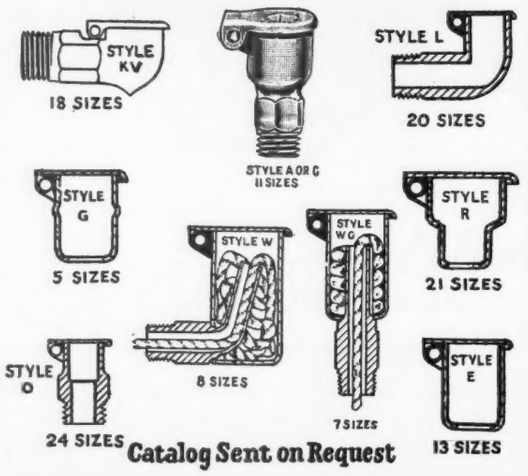
WESTON ELECTRICAL INSTRUMENT CORPORATION
136 Weston Avenue, Newark, N. J.

GITS BROS.

Standard of Comparison

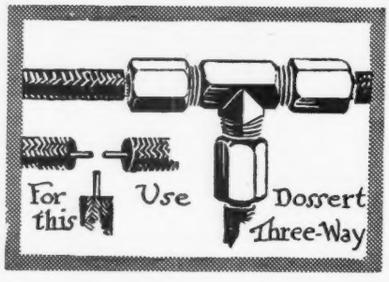
Better Oilers

Quality-Schedule Delivery-Price



Catalog Sent on Request

Gits Bros. Manufacturing Co.
1940 S. Kilbourn Ave. Chicago, Ill.

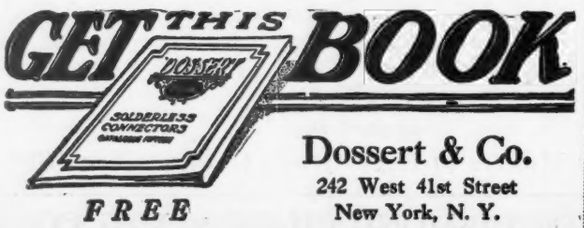


To make a 3-way splice

Better conductivity at the joint than in the wire itself, is a condition you always have with any of the Dossert connectors.

—all due to the Dossert principle—the tapered sleeve.

The Dossert 20th Year Book shows you the economy these connectors give you.



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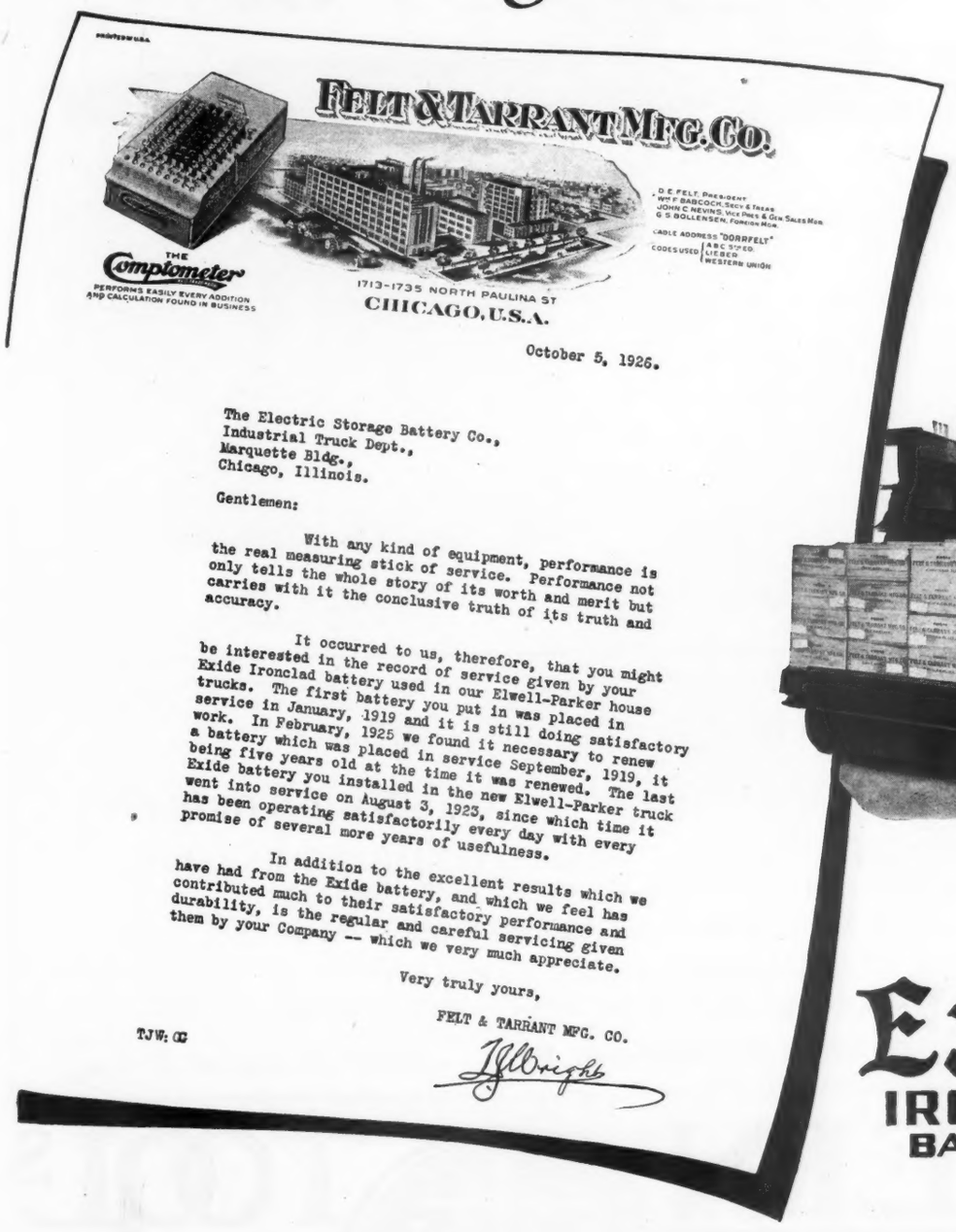
Dossert & Co.
242 West 41st Street
New York, N. Y.

"Performance is the real measuring stick of service!"



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THE Comptometer PERFORMS EASILY EVERY ADDITION AND CALCULATION FOUND IN BUSINESS

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CABLE ADDRESS "DORRFELT"
CODES USED: ABC 5TH ED. LIEBER WESTERN UNION

October 5, 1926.

The Electric Storage Battery Co.,
Industrial Truck Dept.,
Marquette Bldg.,
Chicago, Illinois.

Gentlemen:

With any kind of equipment, performance is the real measuring stick of service. Performance not only tells the whole story of its worth and merit but carries with it the conclusive truth of its truth and accuracy.

It occurred to us, therefore, that you might be interested in the record of service given by your Exide Ironclad battery used in our Elwell-Parker house trucks. The first battery you put in was placed in service in January, 1919 and it is still doing satisfactory work. In February, 1925 we found it necessary to renew a battery which was placed in service September, 1919, it being five years old at the time it was renewed. The last Exide battery you installed in the new Elwell-Parker truck went into service on August 3, 1923, since which time it has been operating satisfactorily every day with every promise of several more years of usefulness.

In addition to the excellent results which we have had from the Exide battery, and which we feel has contributed much to their satisfactory performance and durability, is the regular and careful servicing given them by your Company -- which we very much appreciate.

Very truly yours,

FELT & TARRANT MFG. CO.

TJW: CC

Exide
IRONCLAD
BATTERIES

The performance of Exide-Ironclad Batteries receives another striking tribute

IT is impressive when a prominent electric industrial truck user speaks in such glowing terms of the performance of Exide-Ironclad Batteries. Yet the Felt & Tarrant Mfg. Co. is only one of the hundreds of firms that have discovered what the dependability and long life of Exide-Ironclad Batteries can do to lower material-handling costs.

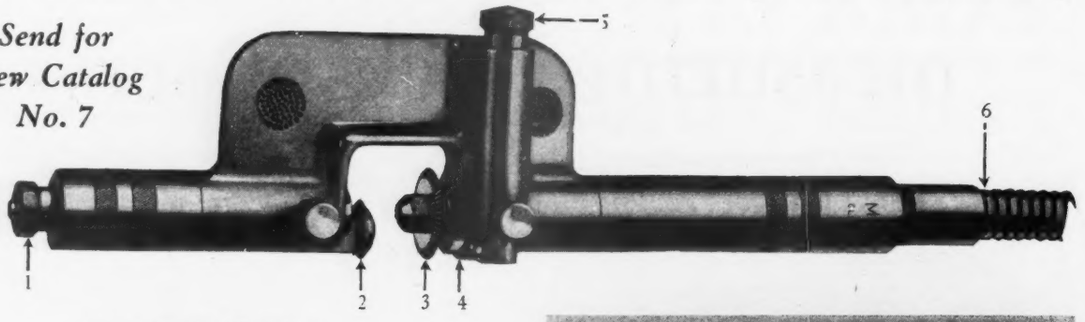
It will pay you to know all about this remarkably dependable battery. Write now for a copy of our booklet, "Facts for consideration in selecting a Storage Battery," form number 2865.

THE ELECTRIC STORAGE BATTERY COMPANY, Philadelphia

Exide Batteries of Canada, Limited, 153 Dufferin Street, Toronto

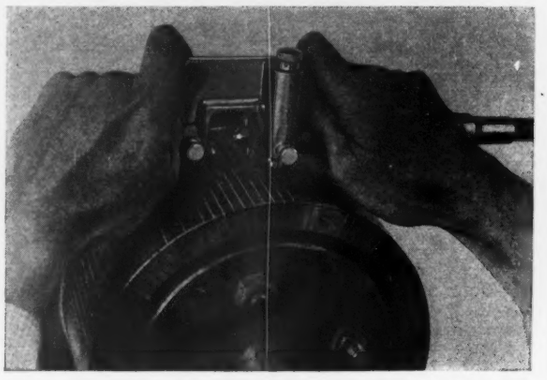
IMPERIAL UNDERCUTTER (New Model)

Send for New Catalog No. 7



DESCRIPTION

1. Micrometer screw to adjust "V" shaped slot guide.
2. "V" shape roller guide to ride in an adjacent slot to guide the cutter.
3. "V" shaped milling cutter which cuts a "V" shaped slot. Slotting saws for "U" shaped slots may be used if preferred.
4. Depth gauge to regulate depth of slot.
5. Micrometer screw to adjust depth gauge.
6. Flexible shaft operated by ¼ h.p. 1750 r.p.m. motor.



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Impervious Varnish Company

Insulating Varnishes and Finishing Enamels

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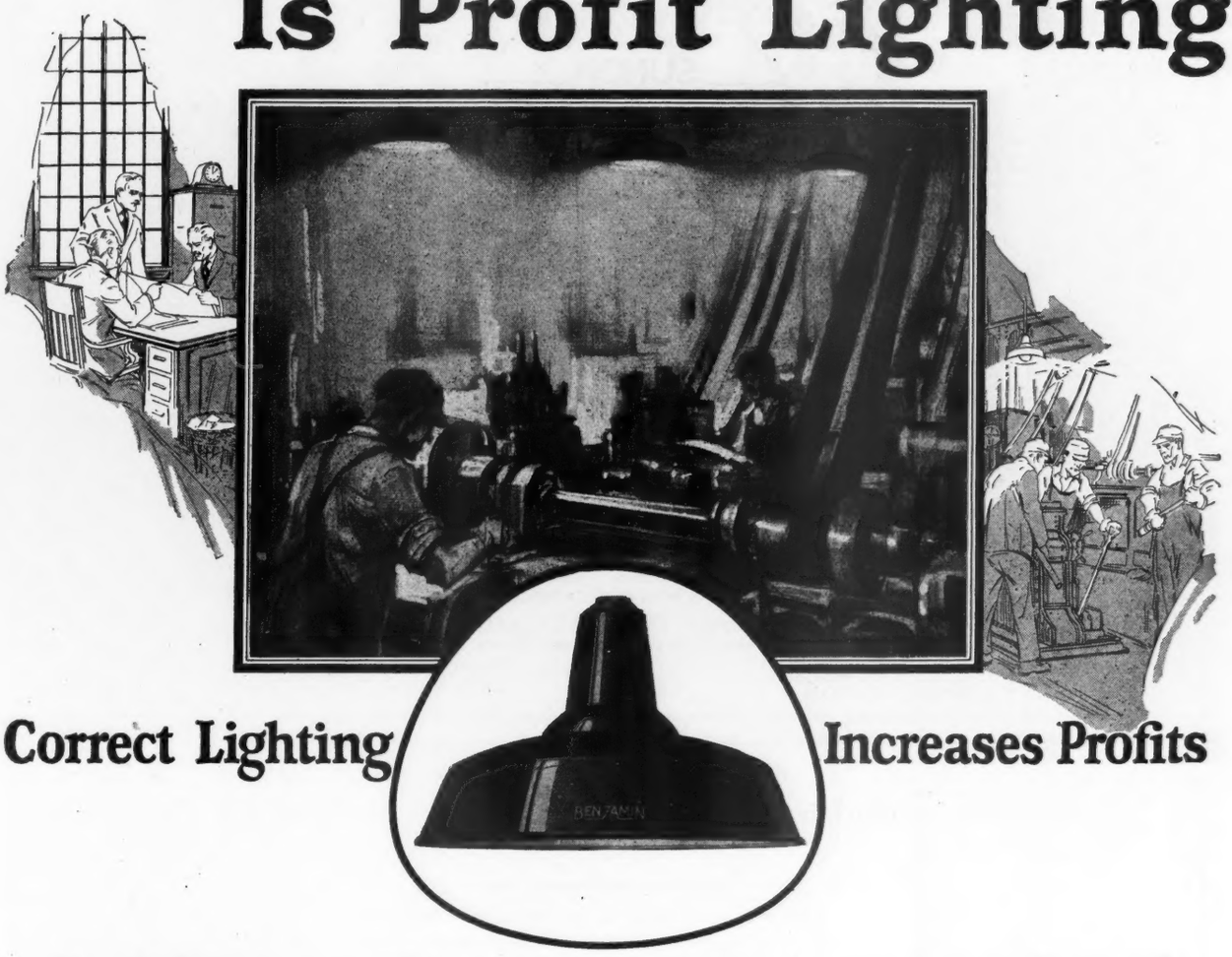
Since 1857

Mathias Established 1857 KLEIN & Sons Chicago Ill USA

Planned Lighting Is Profit Lighting



Correct Lighting Increases Profits

Good lighting is as essential to production as modern machinery or proper arrangement of operations. Unless men can see well they cannot do nor give their best. No matter what the program may be the final test of accuracy and good performance will rest upon ability to see.

The time has passed when men can be driven. They must be led into greater productiveness through the stimulus of proper surroundings and adequate facilities.

In thousands of plants that are operating on the profit side, Benjamin industrial lighting equipment is a saving factor in their efficiency.

When Correct Industrial Lighting is under consideration our Catalog 24 will be found very helpful. Our nearest office will gladly supply a copy.

Benjamin Electric Mfg. Co.

New York: 247 W. 17th Street
120-128 S. Sangamon Street Chicago
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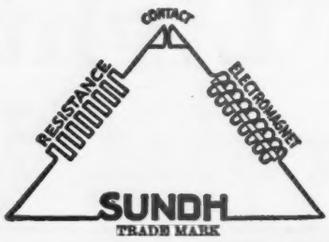
Manufactured in Canada by the Benjamin Electric Mfg. Co. of Canada, Ltd., Toronto, Ontario.

Benjamin-Starrett Panel Boards

BENJAMIN TRADE MARK

Benjamin Industrial Howlers

The elements 

of our Business

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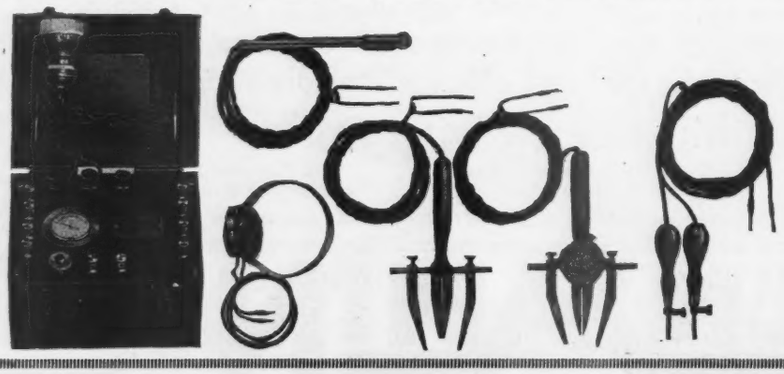
The Enduring Insulation **STERLING** Used the World Over

Submit your problems to our Research Engineers
Engineer's hand-book sent on request

THE STERLING VARNISH COMPANY

Pittsburgh, Pennsylvania - - Manchester, England

CENTURY Field and Armature Tester, A. C. Type



Just the thing you have been looking for —a field and armature tester that can be operated from your A.C. Lighting circuits. Simply remove a lamp from its socket and screw in the attachment plug. Readings for fields are direct from dial and pointer. Armatures can be tested using either Meter or Receiver type of fork. Besides accuracy and dependability, this tester is so simple to operate that anyone can use it. It can be furnished for use with any commercial frequency. Write for full information.

The Century Electrical Co.
100-102 Randall Ave., Syracuse, N. Y.

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Your requirements of your friends are probably many, but foremost among them is reliability—reliability at all times and under all circumstances. Kuhlman Transformers are like true friends—you can always depend upon them to serve you unfailingly and with high all-day efficiency.

The Kuhlman Organization is a friendly one—ever ready and willing to be of service—to help you out of a difficulty—to make an extraordinary delivery to meet requirements you could not anticipate—to aid in solving your transformer problems.

Write the office nearest you.

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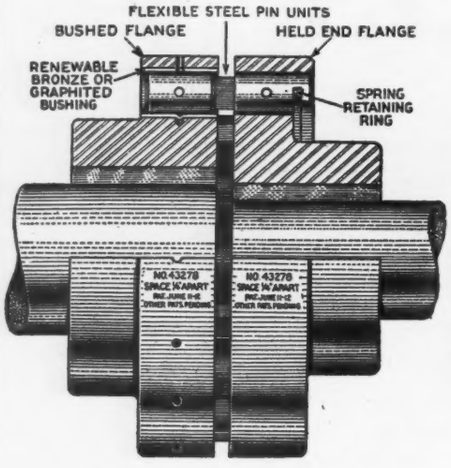
Cincinnati..1308 Union Trust Bldg.
Cleveland.....500 East 102d St.
Dallas.....Unit 2, Santa Fe Bldg.
Denver.....1843 Wazee St.
Detroit...3-260 Gen. Motors Bldg.
Indianapolis
202 Indiana Term'l Warehouse
Los Angeles
316 American Bank Bldg.
Milwaukee.....1031 Clybourn St.
Minneapolis...1004 Marquette Ave.
New York.....300 Madison Ave.
Omaha.....727 W. O. W. Bldg.
Philadelphia.....1700 Walnut St.
Pittsburgh.....839 Oliver Bldg.
Saint Paul.....1479 Blair St.
Salt Lake City
134 W. 2nd South St.
San Francisco.....Call Bldg.
Seattle.....314 Seneca St.
Toledo.....424 Spitzer Bldg.
Tulsa.....318 So. Boulder St.
York, Pa.....335 W. Market St.

KUHLMAN TRANSFORMERS

POWER-DISTRIBUTION-STREET LIGHTING

A. H. R. Co. says
Since 1916

"Some of our Francke couplings installed 10 years ago, are in service today without one cent having been spent for coupling repairs. Because of our experience we have standardized on Francke couplings."



These improved Francke couplings, in small and intermediate sizes, now have forged steel flanges—greater bore and power capacities, lower cost.

FRANCKE
FLEXIBLE COUPLINGS

For Motor, Turbine, Engine Drives

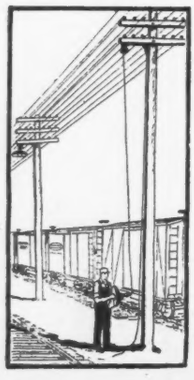
The Francke handles all accidental Misalignments—Out of center in an angular direction and endwise; cushions starting and load shocks; absorbs vibrations; runs in either direction; is noiseless.

In case of excessive misalignment it acts as a safety device saving broken or scored shafts, bearing troubles, etc. However, if more than the usual misalignments are expected, due to non-rigid foundations or for any other reason, two couplings in tandem with an intermediate shaft or a Double, Floating-Ring Type Francke Coupling should be used.

Other Francke Features. Easily mounted, aligned and connected without special tools. All metal, no perishable material. No movement or wear on shaft flanges to cause expensive renewal of complete coupling. Simple and safe.

Ask for Bulletin 37 S

SMITH & SERRELL
Coupling Specialists Since 1912.
26 Washington Place, Newark, N. J.
District Engineers at Pittsburgh, Cleveland, Chicago

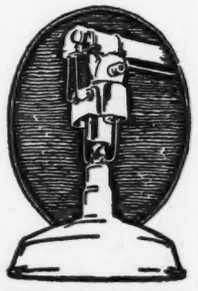


DIRTY REFLECTORS MEAN—
DANGEROUS AND COSTLY LIGHTING

The THOMPSON SAFETY LOWERING SWITCH
—or Disconnecting Hanger

Makes reflector-cleaning easy and safe.
Eliminates climbing and electrical hazards.

Write for Bulletin B-26 for Details



THE THOMPSON ELECTRIC CO., 1438 West 9th St. Cleveland, Ohio, U.S.A.

A-C-E

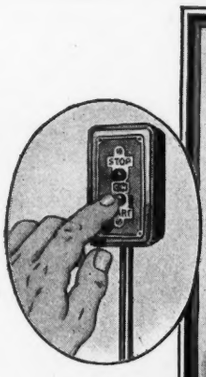
Coil making machines offer the latest in modern equipment for coil making.

Our machines are the simplest and less expensive and are being used by thousands of concerns throughout the world.

Our trial offer will prove the above facts.

Complete information on request.

ARMATURE COIL EQUIPMENT CO.
MANUFACTURERS
2415 Forestdale Ave. Cleveland, Ohio



The trend of industry is decidedly toward Cutler-Hammer Push Button Control. Merely a touch of the proper button right at the machine starts, accelerates, decelerates, regulates the speed or stops the motor as required. The controller is placed in any safe, convenient location. Saves time, affords better control and provides greater safety—a logical step in advance.

This booklet "Industry's Electrical Progress" puts into concise, interesting form the story of savings through modern motor control. Write for your copy today.

Motors by themselves are only brute force

The economies that electric power brings to industry depend on correct motor control

IT seems so simple—and yet in so many plants this basic truth is often neglected.

Motors by themselves are only brute force!

Engrave it on the minds of the men who design *your* equipment. Burn it into the memory of those who specify—those who buy. For today it is the battle cry in the fight to reduce manufacturing costs!

Every motor you put into service offers the opportunity of minimum operating expense. It can save in power costs. It can speed up production. It can save in labor—that major item of manufacturing burden. But you are trifling with opportunity if you leave these possible economies to chance—these economies that result not from the mere installation of motors, but from the production efficiency you are able to obtain through the perfect control of their brute force.

Competitive conditions today demand the accurate powering of equipment. Plan your drives considering the work to be done. That means the choice of motor control equipment first—choice of the type of control equipment that affords maximum speed of production—that ties in closest with the manual operations involved. The proper type of motor can *then* be selected to give maximum results.

Carry this story to the men of your plant! Have them check the motors you have in service. Like many other plants, you will find that modern motor control on many existing drives will pay for itself in a few months—and then add steadily to profits.

If you desire, Cutler-Hammer field engineers will gladly counsel with your plant men or consulting engineers to determine where savings may be obtained—to show them the latest control equipment available for every need. Their recommendations are based on more than thirty years' experience. This service is also offered for the planning of new drives, and their co-operation does not place you under any expense or obligation.

The CUTLER-HAMMER Mfg. Co.

Pioneer Manufacturers of Electric Control Apparatus

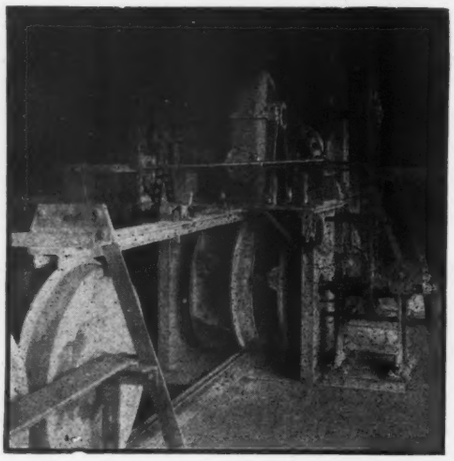
1219 St. Paul Avenue Milwaukee, Wis.

CUTLER-HAMMER

Industrial Efficiency Depends on Electrical Control

REPEAT ORDERS

from Satisfied Customers



Horsburgh & Scott Worm Gear Speed Reducer driving Car Wheel Cleaner, Motor 15 H.P. at 1200 R.P.M. Speed Reduction 40 to 1.

These are a true indication of the value of a product. HORSBURGH & SCOTT WORM GEAR SPEED REDUCERS are repeatedly purchased by concerns who have bought them and found that they have fulfilled our claims for Dependability, Durability and Economical Operation.

The illustration is that of a type B unit, with gear shaft extended in both directions, operating a car wheel cleaner. The first unit, purchased a number of years ago, has not only resulted in repeat orders but also an expression of complete satisfaction from the user.

An engineering department capable of consulting with you on every problem of power transmission or speed reduction is at your service.

The Horsburgh & Scott Co.

"Gear Makers Since '89"

5114 Hamilton Ave. *Gears for Every Industrial Purpose—Worm—Bevel—Herringbone— Spur—Spiral—Hardened Heat Treated Gears—Non-Metallic Gears and Pinions* CLEVELAND, U. S. A.

CORRECT

Commutator Maintenance

To get the best service from your motors and generators, you must keep their commutators in perfect condition.

The Acme Commutator Smoothing Stone and the Aurand, Jr., Commutator Slotter are an ideal combination for the efficient and economical maintenance of commutator surfaces. They do the work accurately, quickly, and easily.

Your name and address on a card will bring full details of our entire line of commutator maintenance equipment, viz:

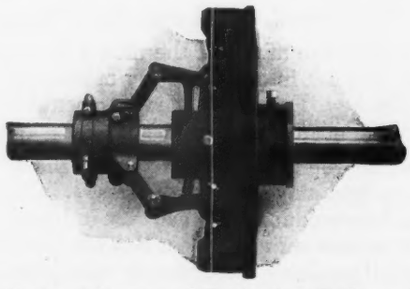
Portable Blowers, Commutator, Polish Cement, Washing Fluid, Turning and Grinding Tools, Fuse Pullers, Air Gap Gauges.

GREEN
EQUIPMENT CORPORATION
MONADNOCK BLOCK CHICAGO, ILLINOIS

WELLER

Steel Plate

FRICTION CLUTCHES



NOTE the Absence of Projecting Bolts or Lugs
Also Compact, Solid, General Lines.

WELLER MADE CHICAGO

We make a Complete Line of
Transmission Machinery
For Belt or Rope Drives
also
Conveying Machinery

Send for Catalogue 35A Transmission Machinery

WELLER MFG. CO.
1820-1856 N. Kostner Avenue, Chicago, Ill.

SALES OFFICES:
New York Buffalo Detroit Omaha

30c More a Day for Lighting Increases Production Six Per Cent

THIS is the actual experience of the Standard Register Company of Dayton, Ohio. While it seems outstanding, over 15,000 plants in various parts of the country, last year, made similar savings.

Practically all of them thought they had good lighting until the change was made. Now they *know* the many benefits obtainable from PROPER lighting and how little it costs to make the change.

BEFORE—Notice the glare on the benches and the shadows on the floors.

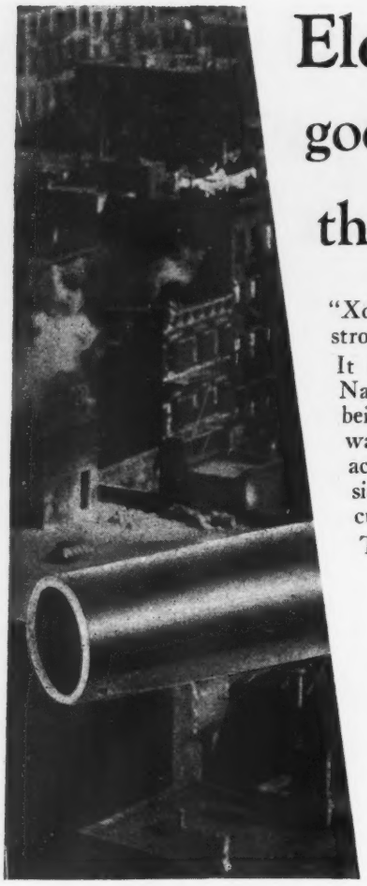
AFTER—And now the room has strong even light without disturbing shadows.

The lighting of the composing room of the Standard Register Company was brought up to standard through recommendations of the Dayton Power & Light Company. In Dayton alone, 58 factories improved their lighting last year.

You, too, can increase your production by bringing your lighting up to the proper standard. Without cost your local electric light company will gladly show you how.

Industrial Lighting Fact No. 2

Industrial Lighting Committee, National Electric Light Association
29 West 39th St., New York



Electroduct— good for the life of the buildings!

"Xduct"—the galvanized conduit with the strong clean threads.

It is smooth inside and outside because it is a National Tube Company's scale free pipe. And being smooth before enameled—it is smooth afterwards. It's easy to handle because of its special acid and alkali resisting coat of enamel both inside and out. "Electroduct" fishes, bends and cuts easily—and has clean perfect threads.

Try it yourself. Let us send you a sample.

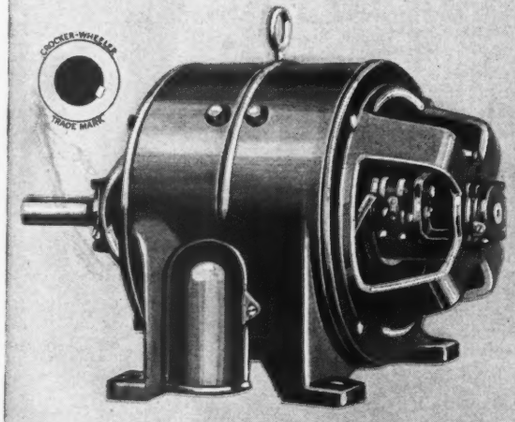
AMERICAN CIRCULAR LOOM CO. TRADE MARK

American Circular Loom Company

90 West Street, New York City

Boston
Philadelphia
Atlanta
Pittsburgh
Cleveland
Buffalo
Chicago
Denver
Portland
Los Angeles

CROCKER-WHEELER



D. C. and A. C. Motors from ½ H. P. up.
D. C. and A. C. Generators and Motor-Generator Sets from 100 Watts up.

CROCKER-WHEELER ELECTRIC MFG. CO.
AMPERE, NEW JERSEY
Branch Offices in Principal Cities
Foreign Distributor: International Standard Electric Corp.

MOTORS & GENERATORS

De Laval

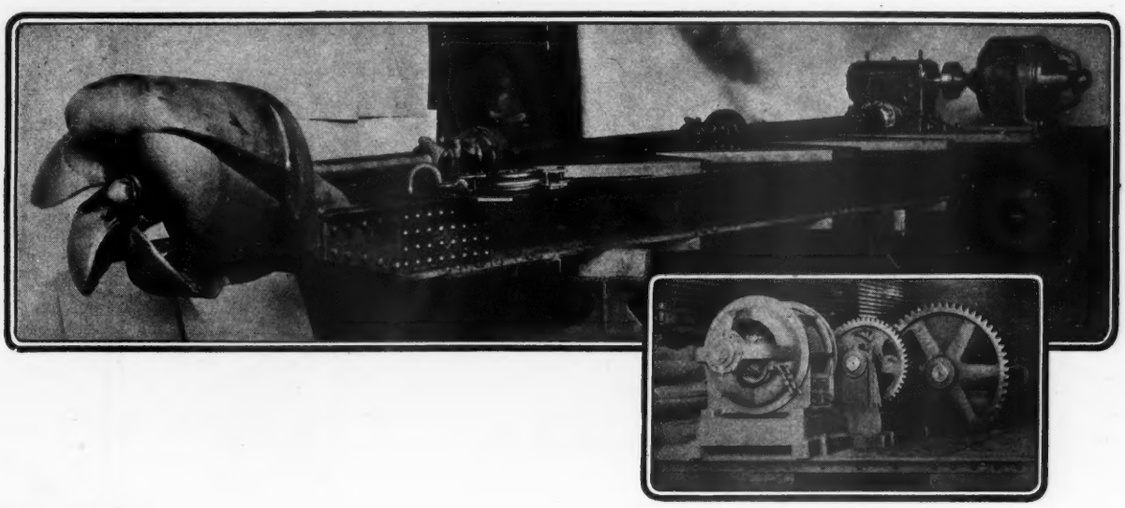
Worm Reduction Gear

A Superior Speed Reducer

Increases Load Capacity

This gear reduces the 600 RPM. of a 30 HP. motor to the 12 RPM. required by a briquetting press.
Ask for Catalog R.

De Laval Steam Turbine Co.
Trenton, New Jersey



When looks are deceiving

Great masses of heavy, open gearing indicate neither strength, efficiency or durability. On the contrary, a compact enclosed, quiet Cleveland Worm Gear Reduction Unit offers all of these features in the highest degree.

The large picture above shows the business end of a big suction dredge, the cutter being driven through a Cleveland worm gear unit. As a study in contrasts, note the old open gear drive, pictured in the insert and replaced by the Cleveland drive.

This dredge has been plowing around through the Florida marshes for several months without the slightest delay or difficulty due to the drive—a welcome relief from the troubles inherent in the old reduction gearing.

Standard Cleveland Worm Gear Reduction Units are made in a variety of styles and sizes to suit all requirements of industrial drives. Thousands of Clevelands are bridging the gap between motors and driven machines. Their maintenance costs are low and they eliminate production delays. Write for detailed information.

CLEVELAND
WORM & GEAR COMPANY
3254 EAST 80TH ST. CLEVELAND, OHIO

Micanite Sheets for all purposes

Micanite Tape

Micanite Commutator Segments

Micanite Commutator Rings

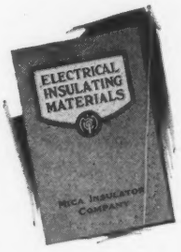
For Motor Doctors!

"Cure them when they get sick!" This used to be the doctor's only job.

Nowadays the doctor's slogan is:—"Keep them from getting sick—keep them well!"

That's a good idea for you Motor Doctors!

Let us help you *keep* your motors on the job. There are some mighty fine prescriptions in the two booklets shown. A post card brings you copies.



MICA INSULATOR COMPANY

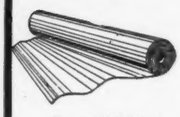
World's Larges Manufacturers of Mica Insulation
Established 1893

New York: 68 Church Street Chicago: 542 So. Dearborn St.
Cleveland Pittsburgh Cincinnati Seattle
San Francisco Los Angeles Victoriaville, Canada

PERFECT MICANITE INSULATOR REG. U.S. PAT. OFF. *Electrical* PERFECT EMPIRE INSULATOR REG. U.S. PAT. OFF. INSULATION

MICA INSULATION OILED CLOTH INSULATION

Empire Tapes (cloth and paper)


Empire Oiled Cloths and Papers

"Armatite" Fish paper and varnished cambric combined

Compounds Varnishes

Bodine Built

Fractional Horse Power Motors

½ and ¼ HP. D.C. Motor

¼ and ⅛ HP. A.C. Motor

CAREFUL attention is given every detail in the design and construction of Bodine Motors. Such extreme care and rigid inspection is costly, but it has made the name "Bodine" on a motor generally accepted as a guarantee of sterling quality and uninterrupted service with absolute satisfaction to the user.

This characteristic means greater user acceptance and satisfaction with better performance of the entire machine to manufacturers.

Learn about the great durability and damage resisting characteristics built into every Bodine Motor.

Write for bulletin No. 1004.

Bodine Electric Company
2256 W. Ohio St. Chicago, Ill.

Small Motors Specialists Over 20 Years

Easy to renew the Trigger-Lock Fingers

New fingers cost time and money to install—use Trigger-lock Fingers with renewable tips. View above shows method of reversing or renewing tips. Each tip will outwear two ordinary fingers on one side; then it is reversed, giving equal wear on the other side. When both sides are worn out a new tip is snapped on the finger while it is on the controller.

Types for every requirement. Ask us for illustrated and descriptive catalog.

Elwell-Parker Tractor

Russell Manufacturing Co.

814 Bath Ave., Niagara Falls, N. Y. 232 Lonsmount Drive, Toronto, Canada

More Money Than You're Making Now

—and how to get it

You have more chance of making big money today in maintenance and repair work than perhaps in any other field of practical electrical work.

Men are needed who can keep things going without serious interruption—men who know how electrical equipment works, what it needs to keep working properly, how to tell what is wrong and how to make it right. The man who equips himself with this information is sure of a good job anywhere—and at big money.

To give you the information needed in work of this nature has been the aim of such well-known electrical experts as F. A. Annett, A. C. Roe, A. M. Dudley, Daniel H. Braymer and others. The electrical industry needs maintenance-and-repair trained men. These practical experts provide the maintenance-and-repair training. It remains only for you to decide if you will take the opportunity offered.

Every year finds new men jumping into the maintenance and repair field. As the common sense of the whole matter is placed before them—the most logical thing in the world to do is to get the information they need. If they are in the electrical field—maintenance and repair stands out as one rich branch—and the books of the men mentioned above stand out as one complete training.

Give this some thought. You owe it to yourself. You will prove to yourself that this is a great opportunity for you. And then act!

Do you want a big-pay electrical job?

The Library of Electrical Maintenance and Repair in its new form *will help you to get it*

You can now have the LIBRARY OF ELECTRICAL MAINTENANCE AND REPAIR in its new form to help you in getting into the bigger and better-paying electrical jobs. The Library tells you what you have to know. It shows you how to do what must be done, and why.

The Library in its new form includes Braymer's Armature Winding and Motor Repair, the new revised edition of Dudley's Connecting Induction Motors, Annett and Roe's Connecting and Testing D. C. Machines, Annett's Electrical Machinery, and Wiring Diagrams of Electrical Apparatus and Installations.

Better than ever—more valuable to you than ever—a great set of electrical helps you need and you will want.

The new 1926 form of the Library of
Electrical Maintenance and Repair

5 volumes—1750 pages—1800 illustrations—library binding

Only $14.00, payable $2.00 a month.

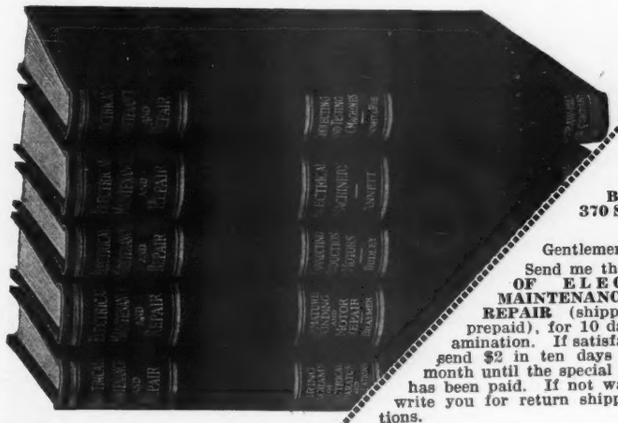
These books cover every phase of electrical maintenance and repair work, from armature winding to the correction of brush troubles. They include many things never before assembled in book form.

They not only tell you what to do in the case of electrical trouble, but they show you how to do it. And when it's done it will be done right! The methods outlined for you by the authors of these books have all been thoroughly tested out in actual practice.

Every chapter is written with the practical man's needs in mind. Instead of discussing the fundamentals involved in any method of working out a repair problem, the ACTUAL PROBLEM is discussed from a how-to-do-it standpoint.

Fundamental laws and rules are discussed when necessary, but there is no hard-to-understand theory or discussion of design. All of the material presented in these five books has been obtained from actual experiences. The Library outlines the practical remedies that have been applied by repairmen all over the country in the solving of puzzling electrical problems. Everything the expert knows about maintenance and repair is given in the books. They prepare you for the big job—they make you well worth the big pay that goes with it. They make your promotion sure.

5 big helps to the big pay job



You need not take our word for the value of these books. You may examine them yourself in your own home for ten days free. No obligation to purchase—no annoying follow-up—no agents—no red tape. We even pay return charges should you decide to return the set.

Take advantage of this liberal plan to examine this library for yourself and see how it can help *you*. Remember, you can't put it over by putting it off. So, ACT—today!

McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York.

Gentlemen:

Send me the **LIBRARY OF ELECTRICAL MAINTENANCE AND REPAIR** (shipping charges prepaid), for 10 days' free examination. If satisfactory, I will send $2 in ten days and $2 per month until the special price of $14 has been paid. If not wanted, I will write you for return shipping instructions.

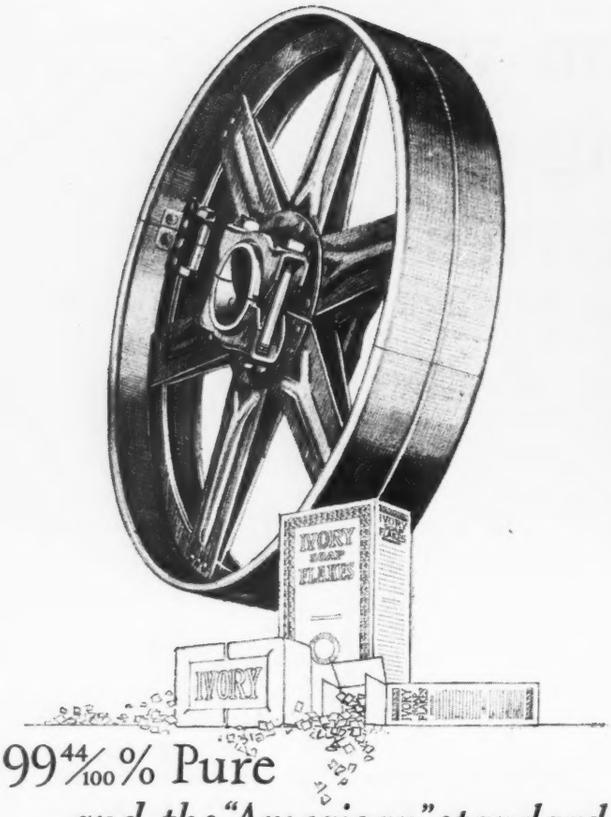
Name .....

Address .....

Position .....

Company .....

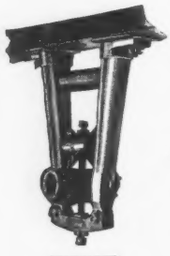
I.E. 12-1-26



99 44/100% Pure
- and the "American" standard is equally high

THIS mark established by the Proctor and Gamble Company for Ivory Soap is very close to perfection. Allowing for the human factor it *is* perfection. That it is so accepted in the public mind has been proved by years of faithful support and by adoption of the phrase as a symbol of all that can be attained.

No such goal is ever reached without the most painstaking attention to details and an unrelaxed vigilance at every step of manufacture.



"American" Pressed Steel Shaft Hangers are light, rigid, efficient and adjustable. Their strong tubular design adds to the good appearance of any shop.

This same care and vigilance have governed the design and making of "American" Steel Split Pulleys for the thirty-some years since the first one was made. Strength with light weight (to impose no unnecessary power load); ease of application (the construction principle which makes it possible to install an "American" Steel *Split* Pulley without stripping a busy line shaft); transmission efficiency (derived from true-running; firm grip on the belt; the center groove that permits air to escape and the pulley arms that cut the air instead of fanning it ;—these and other features of design and construction have doubtless been the reasons why leaders in industry, with exacting standards like those of Proctor and Gamble Company, have equipped their plants with "American" Pulleys.

These "American" principles are fully explained in special literature. Write for it.

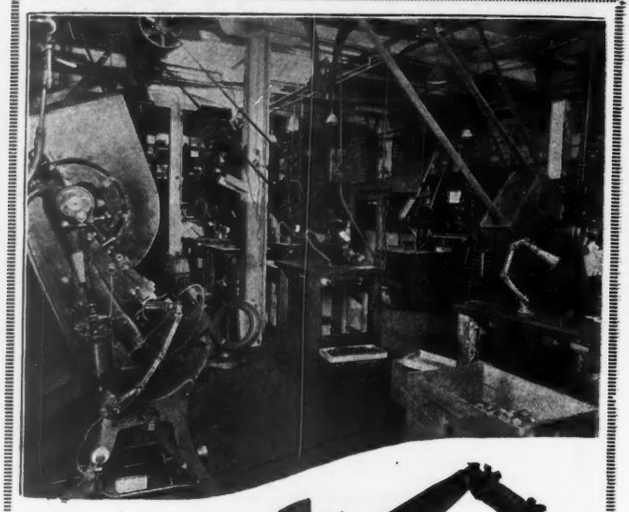
The American Pulley Company

Manufacturers of Steel Split Transmission Pulleys Pressed Steel Shaft Hangers, Pressed Steel Hand Trucks and Pressed Steel Shapes

4200 Wissahickon Avenue Philadelphia, Pa.

For nearest distributor see Mac Rae's Blue Book

AMERICAN
PRESSED STEEL HANGERS | STEEL SPLIT PULLEYS
PATENTED PATENTED



Plenty of Light
absence of Glare

Both conditions are essential to keep up production. American Adjustable Fixtures put the light on the work, not in the eyes, save spoilage and speed up work. Many styles can be built up of standard parts. Write for catalog.

AMERICAN FIXTURE CO.
232 W. Water St., Milwaukee, Wis.

COTTON · ENAMEL · SILK · MAGNET WIRE
TRADE A1 MARK

A-1 MAGNET WIRE

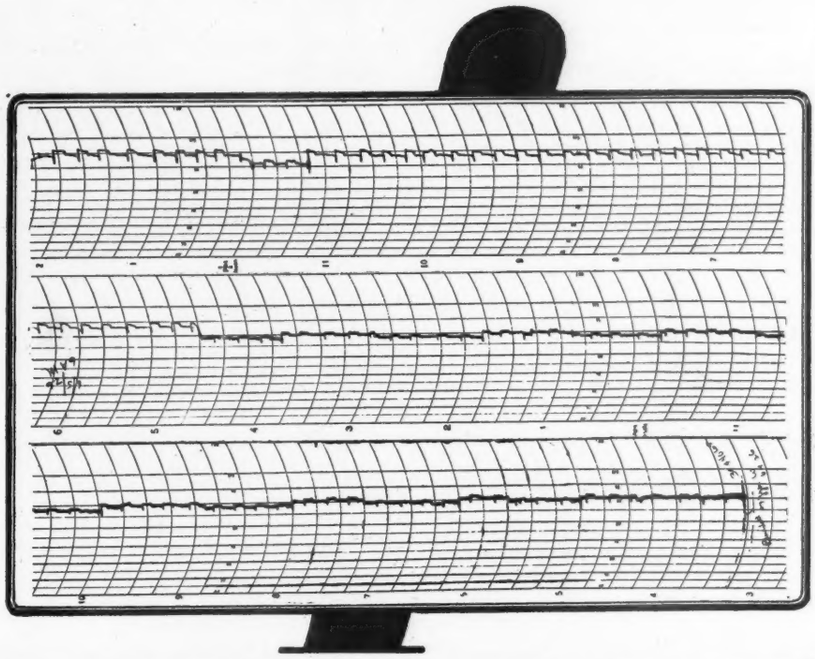
Plain Enamel, Single Cotton Enamel, Single and Double Cotton Covered.

"AMERICAN BRAND"

Weather-proof Copper Wire and Cables
Slow Burning (Und.)
Weather-proof Iron Wire
Slow Burning Weather-proof Copper Wire and Cables
Bare Copper Wire and Cables

Are representative of the highest principles in manufacturing and merchandising in the wire industry.

American Insulated Wire & Cable Co.
Chicago, Illinois



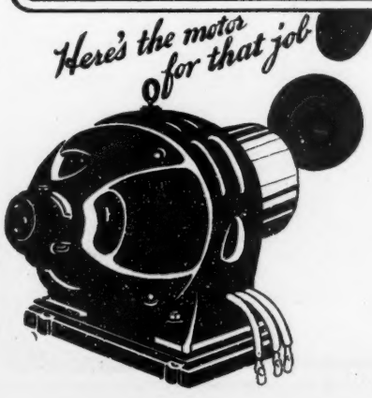
DOES POWER FACTOR COUNT?

Why and How

At the throw of the switch, TR Automatic Self-Start Motor starts on a high resistance squirrel cage, placed at the bottom of the rotor slots. At a certain predetermined speed, a three point centrifugal switch closes the circuit on a low resistance winding at the top of the slot, bringing it into operation and paralleling it with the high resistance winding. The motor then operates as phase wound, constant speed, the two windings dividing the load.

External starters are eliminated. In thousands of installations, neither motors nor switches have ever given trouble. Starting current is exceptionally low, starting torque high, and the motor will carry heavy overload.

This is a brief description. Full details will be found in this bulletin. Write for it today.



It certainly does—

Low power factor means waste power which somebody must pay for.—Even where there is no penalty, it is eventually reflected in rates.

It is necessary to overmotor when ordinary induction motors are placed on hard starting jobs. Overmotoring always causes bad power factor.

TR Self Start Heavy Duty Motors deliver starting torque of 275% to 300%, with starting current averaging 30% under N. E. L. A. requirements. No matter how heavy the start, you can power for running conditions—forget the starting load. Overmotoring is unnecessary.

Result—unusually high power factor for TR.

THIS RECORD SURPRISED US

Above is a 24-hour power factor chart taken by a central station on one 75 H. P. slip ring, and four TR motors ranging from 7½ H. P. to 75 H. P.

P. F. over all is around 90%. *P. F. for TR alone is 96%*—a surprise even to us.

Repeated tests of TR power factor show it to be always high, which with TR's superior operating characteristics makes it one of the most useful motors you can buy. If you standardize on TR, power factor correctives are unnecessary.

The Triumph Electric Corporation

Cincinnati, Ohio

THE ONLY AUTOMATIC SELF-START HEAVY DUTY

TR

MOTOR MADE IN 2 TO 125 H.P.

Facilities behind the instrument

Because of the very exacting nature of their work, instrument makers must depend in great part on operating conditions. For instance, the moving parts of instruments, especially the miniature types, are small and delicate and the clearances are proportionately fine. The Jewell organization gives full consideration to these requirements and supplies them in a complete way. Good illumination—clean surroundings—ample room—proper equipment—in fact every facility that proves of value in maintaining accuracy of the instrument is found here.

Twenty-five years of experience in making instruments that have proven accurate under various conditions assures you of successful results with all Jewell installations.

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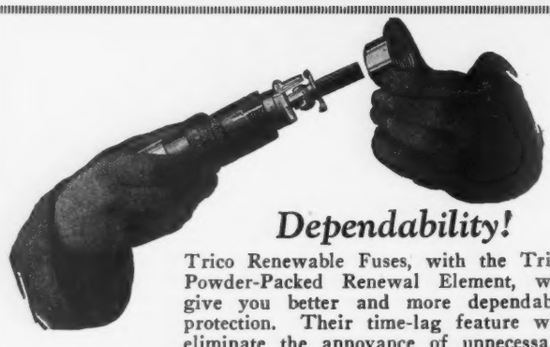
Jewell Electrical Instrument Co.
1650 Walnut Street, Chicago, Ill.



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Trico Renewable Fuses, with the Trico Powder-Packed Renewal Element, will give you better and more dependable protection. Their time-lag feature will eliminate the annoyance of unnecessary blowing of fuses on starting and momentary overloads.

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For Over Twenty Years

They have given satisfactory service under the most severe operating conditions.

BURKE MOTORS and GENERATORS

BURKE ELECTRIC CO.
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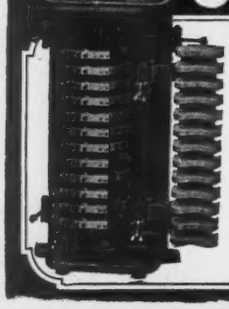

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BALL BEARINGS
for Electric Motors

If you are interested in applying ball bearings to your present motors, let our Engineering Department help you in determining the correct design and mounting. On new motors, manufacturers will supply Fafnir Ball Bearings if you so specify when ordering.

FAFNIR

"..... less trouble with windings .. no oil gets in ..."

Now that the chief engineer of a large foundry has changed over to ball bearing motors, he writes, *"We have less trouble with the windings and commutators due to the fact that no oil gets in . . ."*

As in this instance, so in hundreds of others. Experience shows that ball bearings do cut down motor trouble and failures. That ball bearings do get rid of the worries, time out, and costly expense of so many rewinding jobs caused by oil-soaked insulation and short-circuited coils.

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Makers of high grade ball bearings for every purpose—the most complete line of types and sizes in America.

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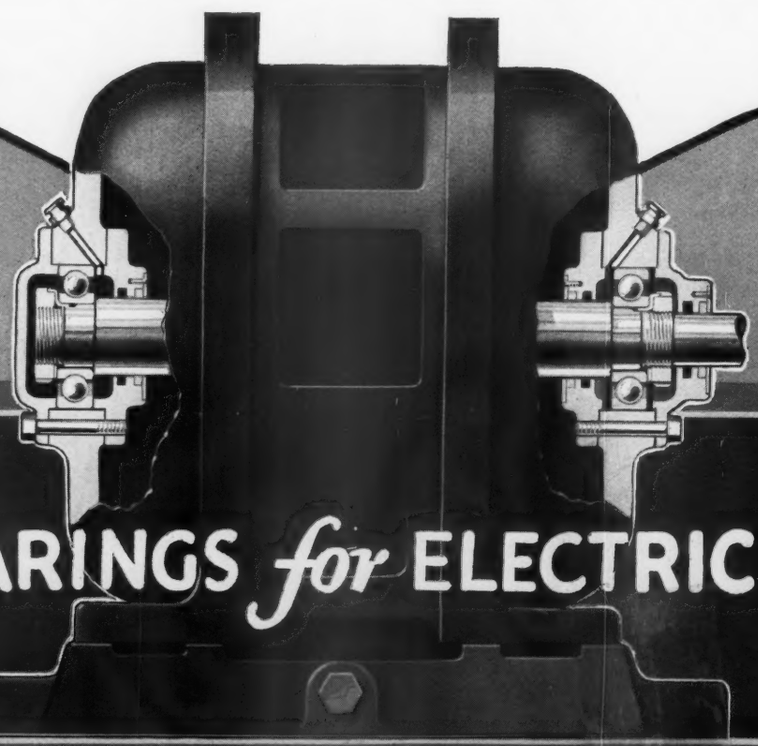

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Electro Dynamic Motors
1880 1926

The Pioneer Manufacturer of Ball Bearing Motors

Electro Dynamic has not only pioneered in the development of ball bearing motors but also has maintained consistently a policy of designing and building along the most advanced lines.

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ROLLWAY BEARINGS

Rollway Bearings and Housings stop motor bearing troubles

On your old motors as well as on new ones, you can eliminate bearing troubles and the host of other troubles that originate in sleeve bearings by installing Rollway bearings and Housings. The Rollway Bearing Company has furnished bearings and housings for changing over thousands of sleeve bearing motors and is prepared to furnish change-over equipment for any standard motor. Send name-plate data on your most troublesome motor or our nearest engineering representative will call on request.

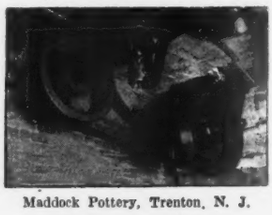
Rollway Bearing Company, Inc. **Syracuse, New York**

slip!

A slip of the belt is no fault of the belt

Tightening the belts does not prevent belt slip. This is a scientific fact. Cling-Surface preservative absolutely prevents slipping and enables you to run the belts slack, thereby increasing the arcs of contact, preventing hot-boxes, and often quadrupling the life of your belts. Besides, Cling-Surface prevents a large per cent of shut downs. The coupon represents an opportunity for you to effect large savings of power. In addition it will bring you the means of saving belts, machinery, fuel and money. Mail it today.

Cling-Surface—preserver of belts—has been made for thirty years by the only company whose sole product is belt treatment. It is used in every country of industrial importance in the world. It saves belts and machinery. It increases transmission efficiency and prevents all loss due to slipping.



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☐ 3 gal. tin at $3.40 gal.
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Company ..... Attention.....

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"MEG" Insulation Tester

Generates 500 volts, d.c.
Range 0 to 100 Megohms

How do *you* test insulation?

ARE you *guessing* at this important element of your electrical equipment—waiting for weak insulation to give trouble? Or do you attack the problem in the manner described in our latest "Megger" Catalog?

This New Catalog 1145-E describes all of our "Megger" Instruments including the "Megger" Testing Sets, "Bridge-Megger" Testing Sets, "Meg" Insulation Testers, "Super-Meg" Insulation Testers and "Megger" and "Meg" Ohmmeters. It indicates how they are used in all branches of electrical work and gives some timely suggestions about the type and range of "Megger" Instrument to choose.

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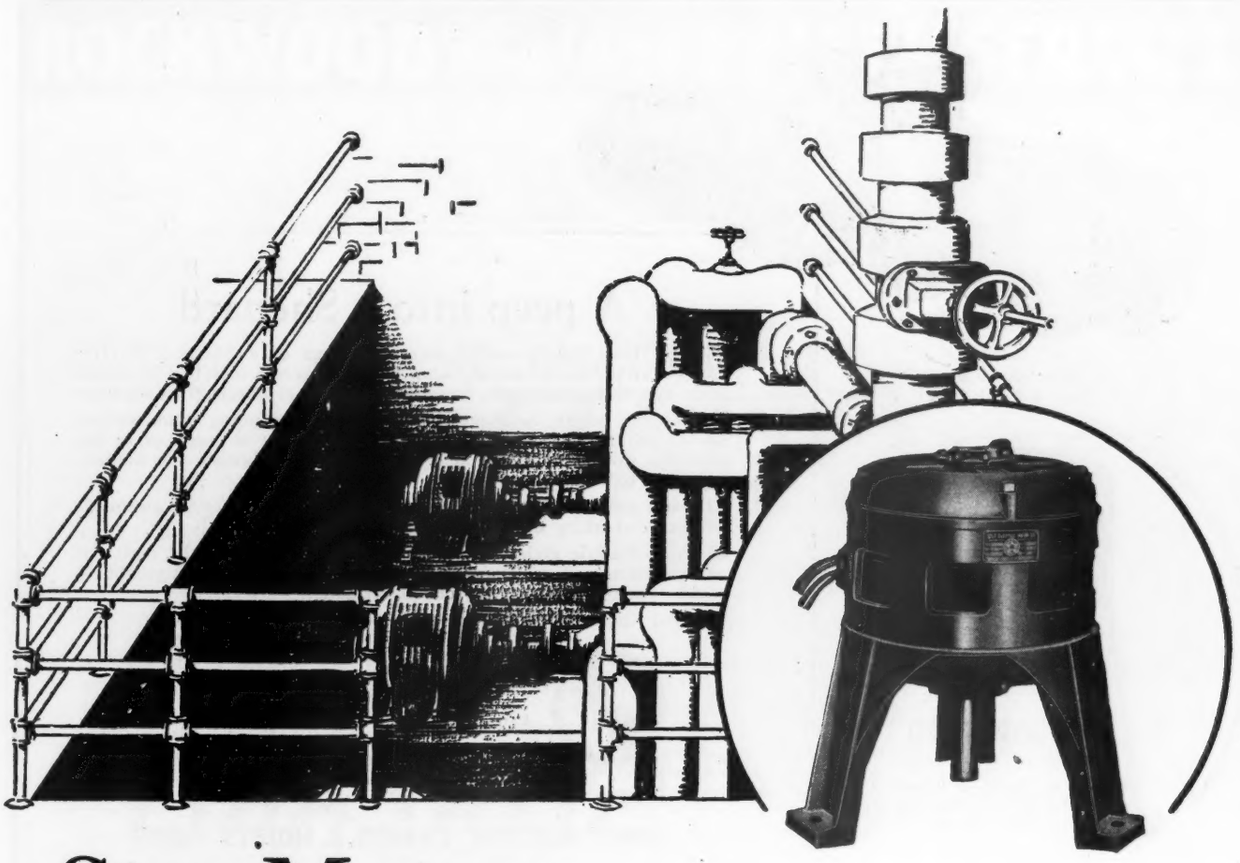

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Centrifugal—Rotary—Plunger

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The high starting torque requirements of plunger or slow speed rotary pumps are fulfilled by the Star double squirrel cage motor. This motor in sizes to 50 h.p. may be operated by an automatic switch, as it requires no compensator or rheostat.

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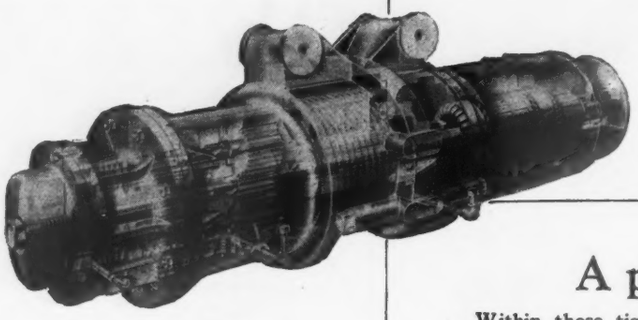

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Within those tightly sealed metal housings of a Shepard Electric Hoist is an orderly arranged, balanced mechanism completely protected from dirt, dust, dampness, fumes and varying atmospheric conditions.

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415 Schuyler Ave., Montour Falls, N. Y.
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Largest Manufacturer of Electric Hoists in America

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A new type of fire protection for those electrical hazards as well as other incipient fires. The liquid used is an absolute non-conductor of electricity and will not damage anything but fire. Built both in gallon and two gallon sizes.

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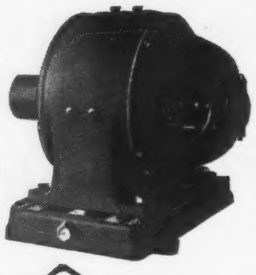

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To Deliver Pulley Service

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Service Stocks *from* Coast to Coast

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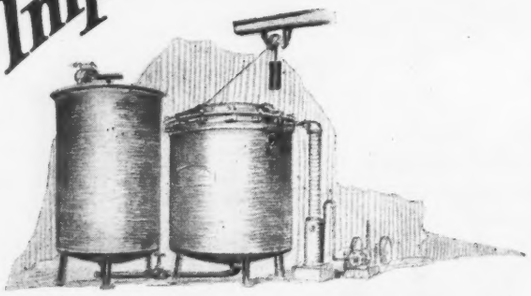

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assure proper and uniform penetration without waste of time or power

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The SIXTH SENSE of Industry

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BROWNING SPREADER?

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Write us for descriptive literature.

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Tin-Plate

Picks Up
Tilts
Transports and
Stacks

All accomplished electrically

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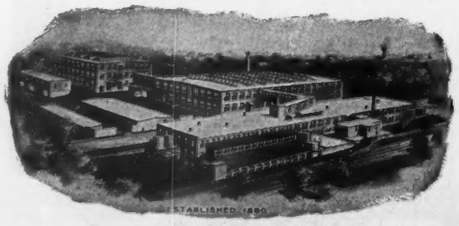
Manufacturers of Cotton Yarns in Fast Colors
Glazed Cotton Yarns
"Sewing and Stitching Threads for All Industries"



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WORCESTER, MASS.

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For safe, permanent wiring in and around electric ovens

Deltabeston stove wire is insulated with a wall of especially treated asbestos roving, 1/32 of an inch in thickness, over which is woven an asbestos yarn braid. Because of its compact and durable asbestos insulation adhering strongly to the conductor, and its remarkable resistance to abrasion, this is an ideal wire for the use of both manufacturers and electric contractors in and around electric ovens.

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Do you have DESTRUCTIVE SPARKING?
Are your BRUSHES wearing GROOVES?
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Eliminate all these troubles and Prolong the Life of Machines

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The original and improved

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over 20 years in service

Let us equip a Generator or Motor for *you.* Make its *final acceptance* subject to your *approval after any reasonable period of operation.*

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TYPE B

"Perfect Contact"

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No more replacing of switch and fuse clip or fuses due to heat, overloading dust, vibration, moisture or corrosion.

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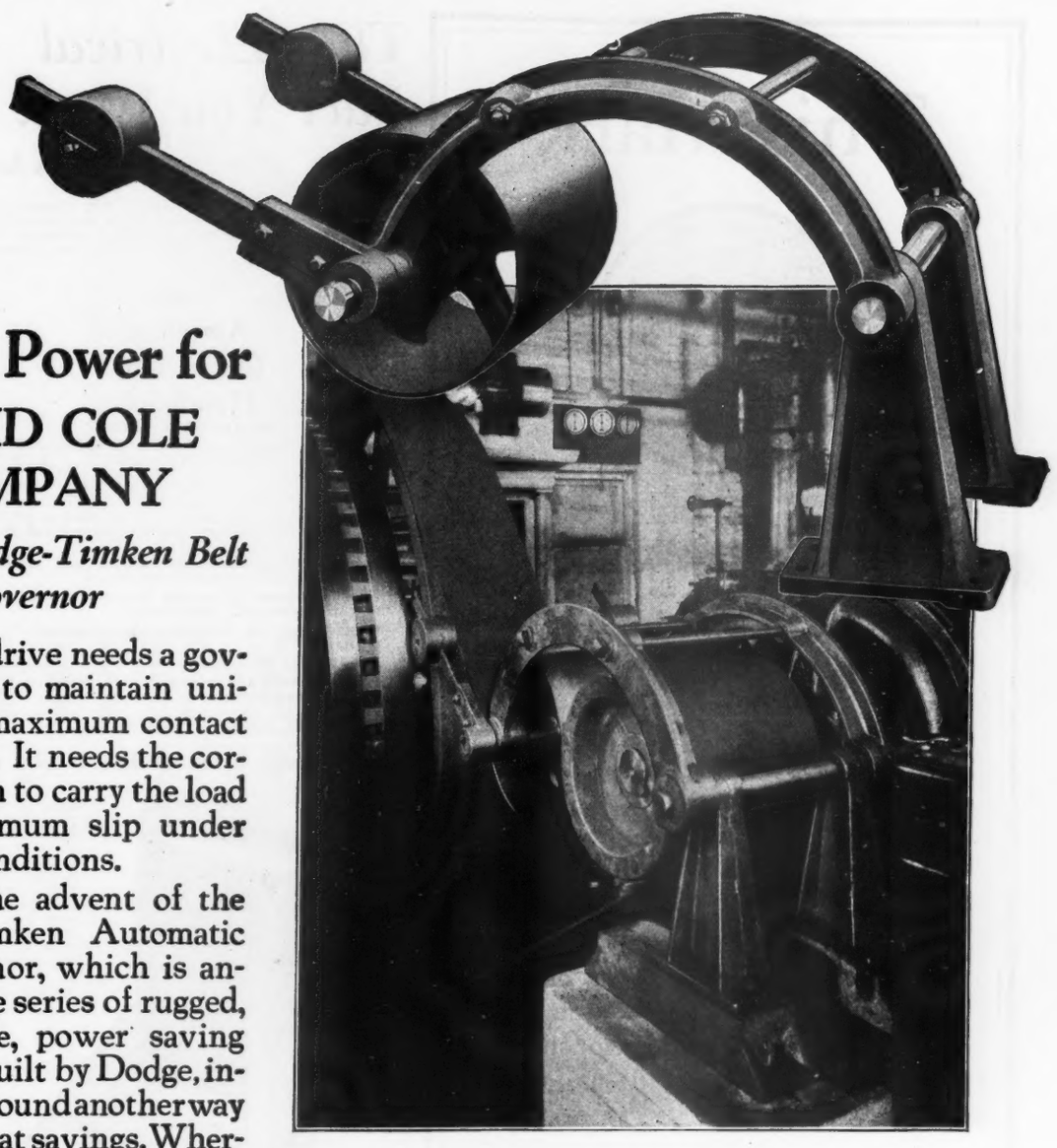

Saving Power for DAVID COLE COMPANY

With a Dodge-Timken Belt Governor

A BELT drive needs a governor to maintain uniform and maximum contact on pulleys. It needs the correct tension to carry the load with minimum slip under varying conditions.

With the advent of the Dodge-Timken Automatic Belt governor, which is another of the series of rugged, trouble-free, power saving products, built by Dodge, industry has found another way to effect great savings. Wherever it is in use it is substantiating every claim for it.

Its application to all industry has been exceedingly successful. Above, is an illustration showing it in operation in the David Cole Co., Omaha, Neb. The Dodge-Timken Belt Governor can be applied to horizontal, angle or vertical drives. It is equipped with Timken Tapered Roller Bearings, which are designed for high-speeds, heavy loads, continous operation and severe service.

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DODGE MANUFACTURING CORPORATION, Mishawaka, Indiana

Power Transmission—Material Handling—Special Machinery

This Mark

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Look for it on all enameled steel reflector installations where Abolites are specified.

It also stands for highly efficient lighting and a dependable product. One which the engineer can specify and know that his requirements will be fully covered.

To the user, Abolites offer a flexible equipment, mainly because of the various types of holder sockets and interchangeability of reflector shades to meet changing conditions in his plant.

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That Electrical Fact You Want

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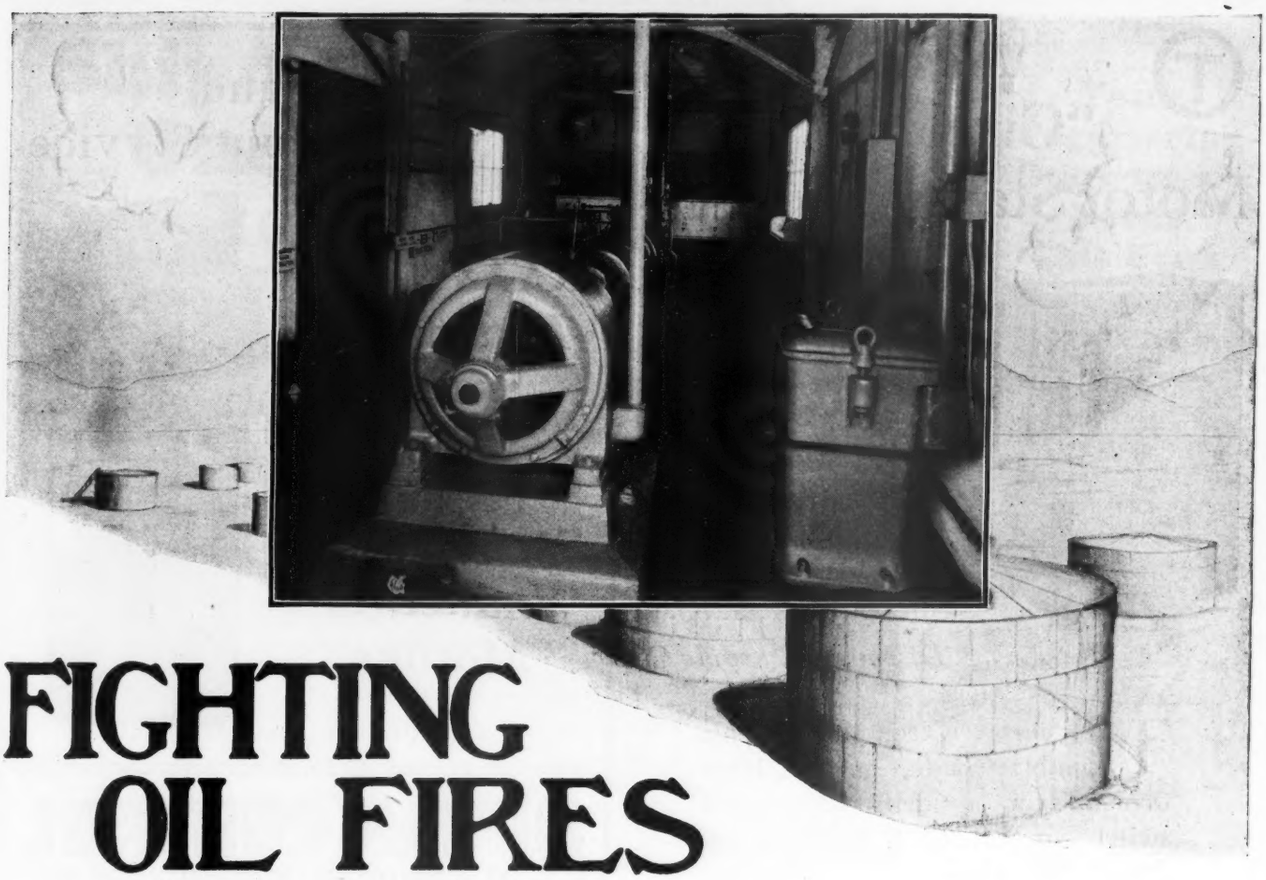

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Every precaution is taken by the large oil companies to prevent fire but they are well equipped to fight a fire and prevent its spreading if one does occur.

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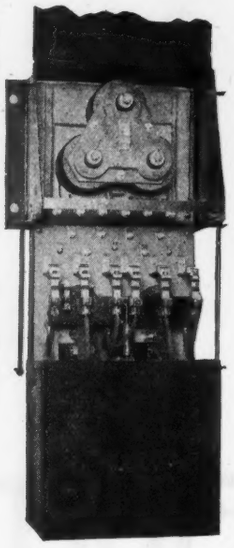

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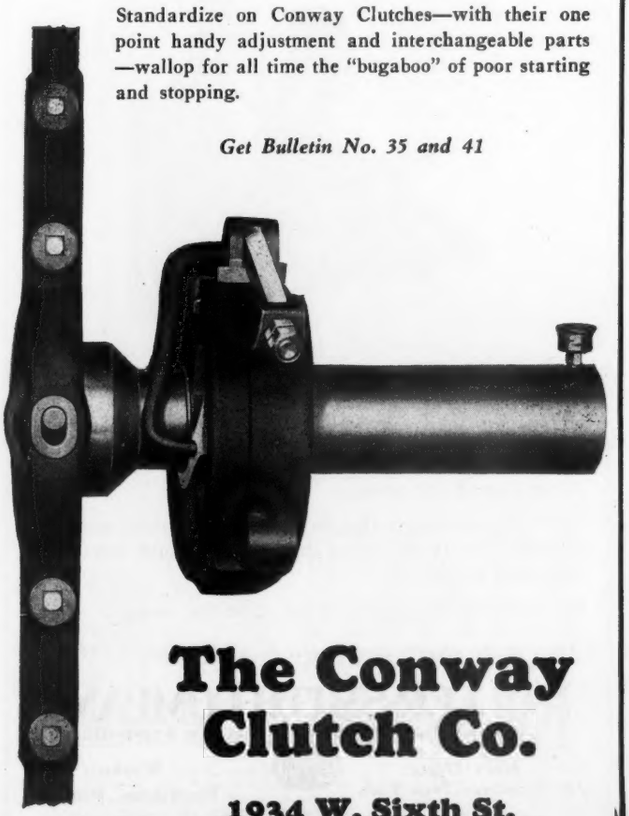

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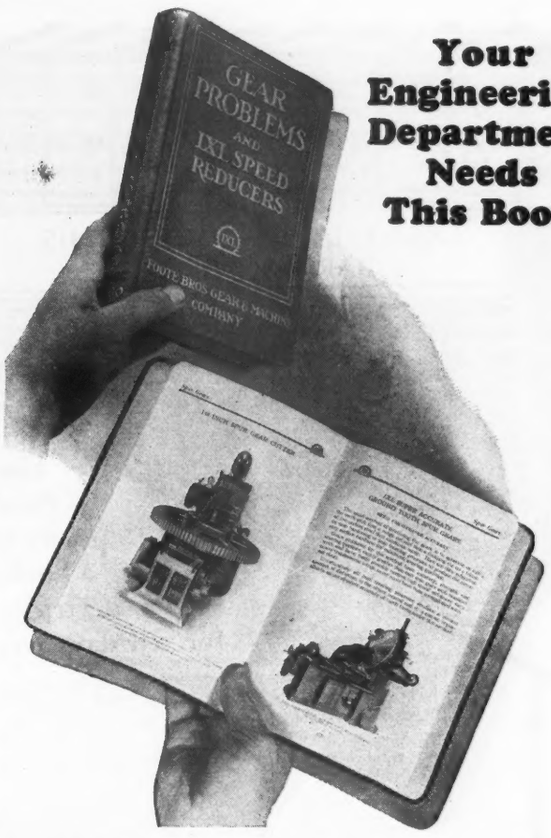

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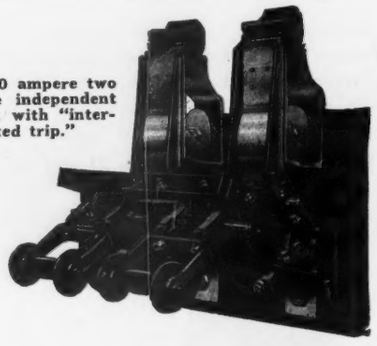

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It is, however, an established certainty that the handling of merchandise or materials constitutes almost ninety percent of the making.

It is also true that after the manufacture, the handling continues to add to the cost but not to the value.

Here is shown the end of the line of conveyors that work for Buhl and Sons, of Detroit, Michigan.

The photograph shows the storage line from which the baskets of unassembled orders are taken as they come from the Spiral Chute and Gravity lines that unite all floors.

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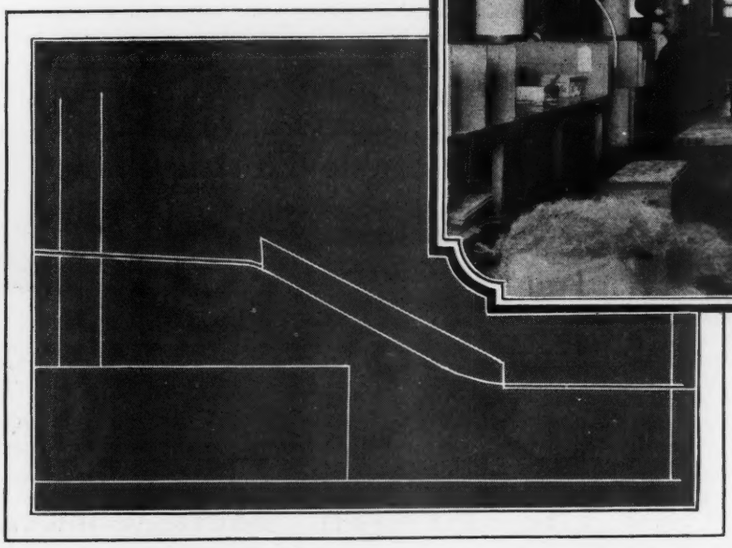
The drawing on the left shows: The Gravity line and slide as it runs from a Spiral Chute over a packing counter to a storage line of rollers. The order clerks for Buhl fill orders. The shipping clerks and checkers, check, pack and ship. **They Do No Needless Handling.** The conveyor saves their time.



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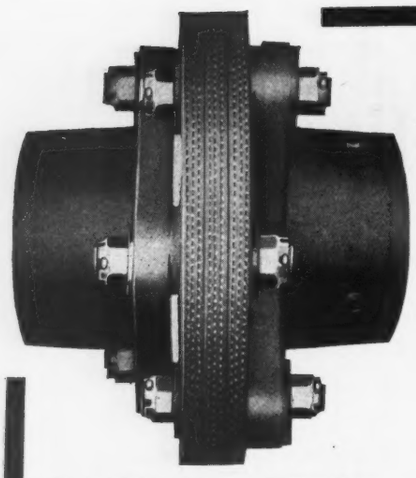
Cable Address: Gravity



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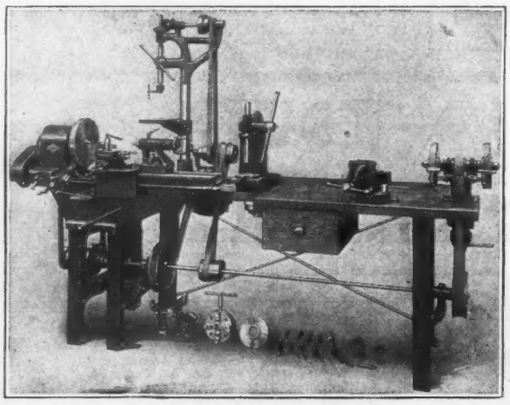

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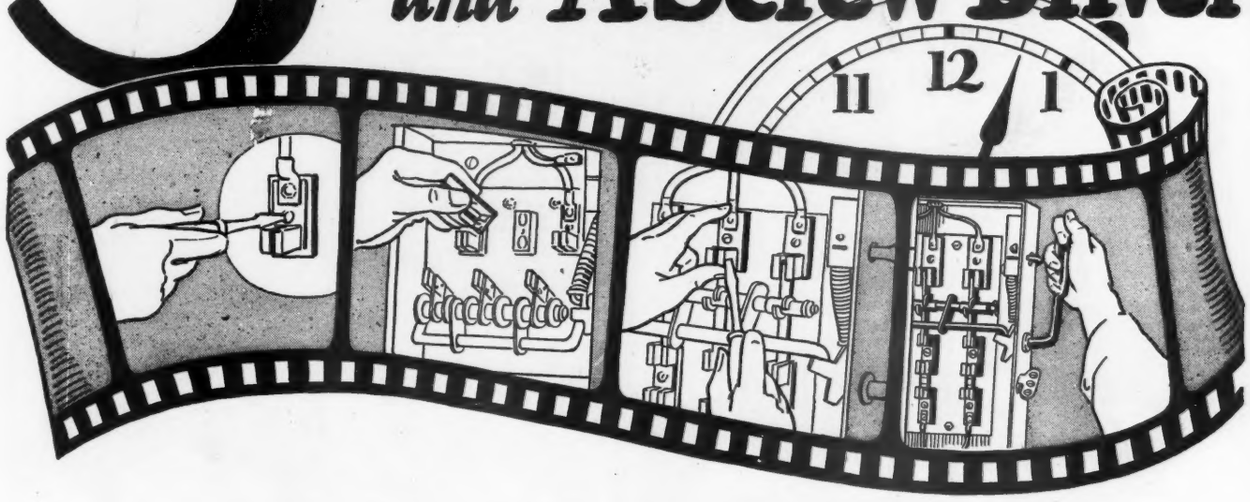

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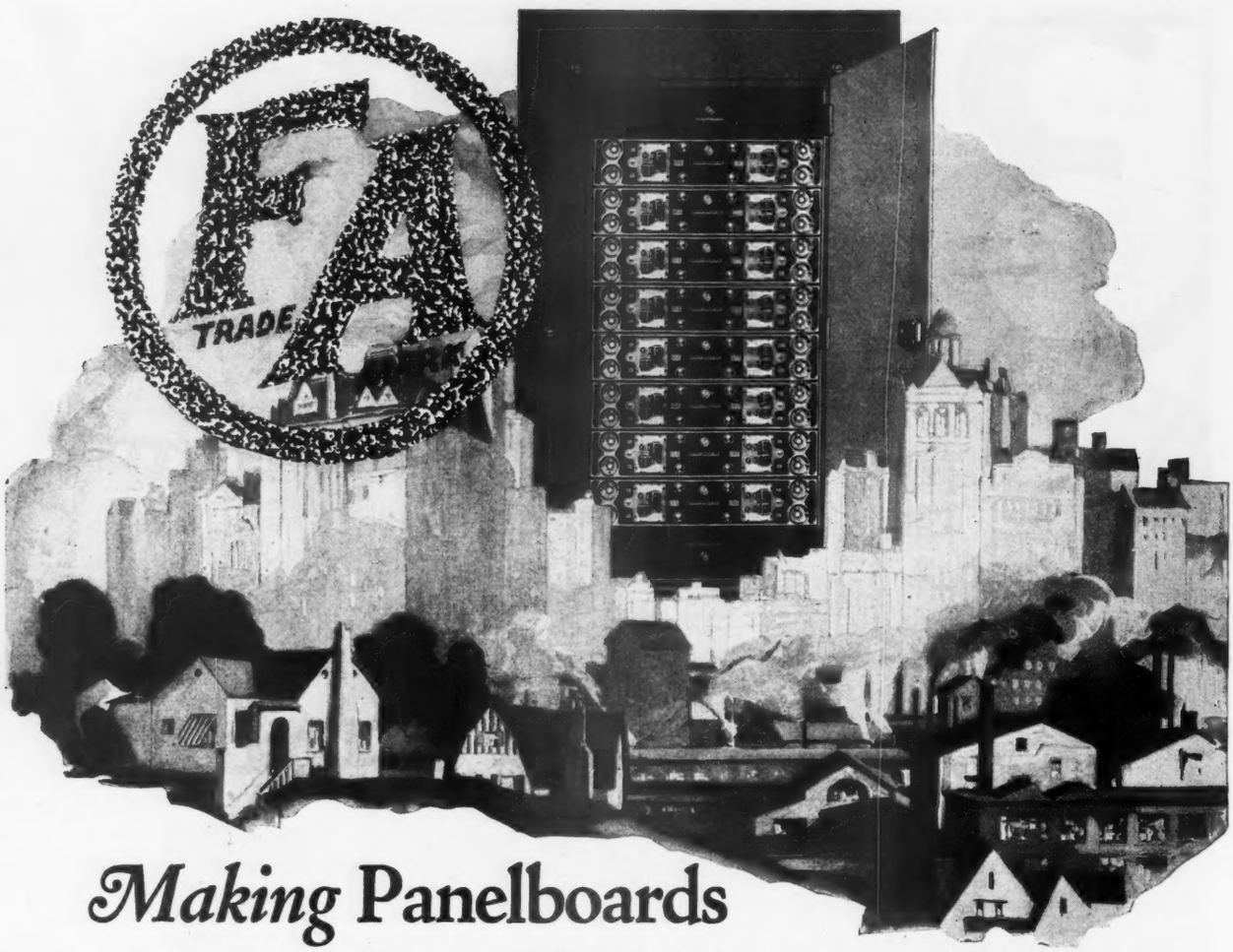

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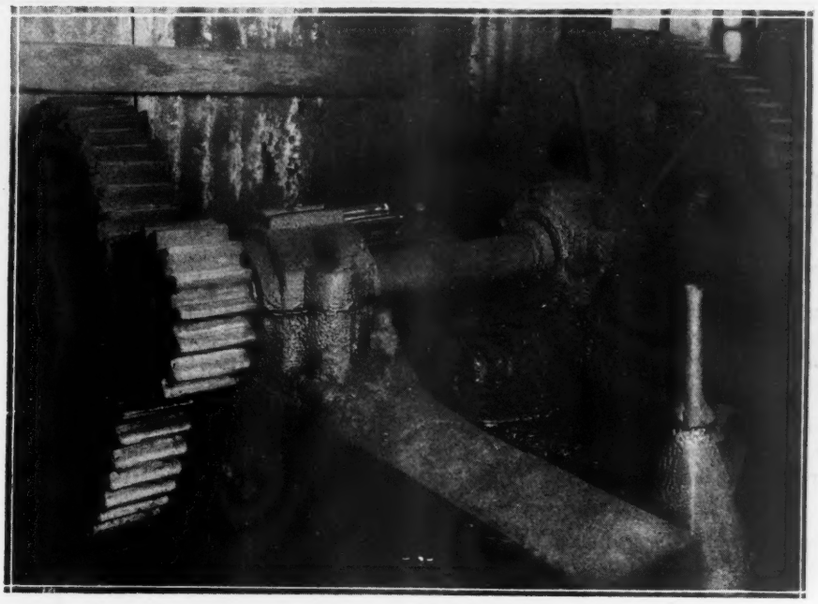
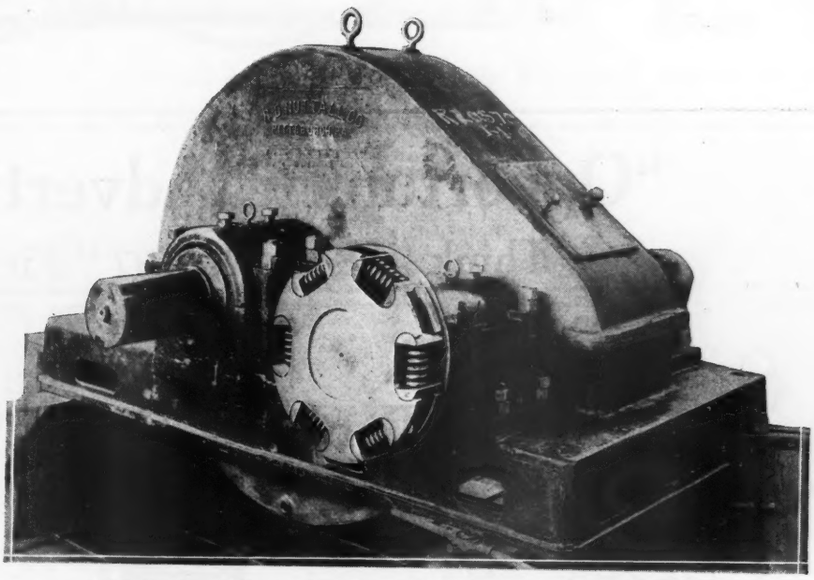


They used to reduce speed this way; in fact a good many still do.

Open gear speed reduction set—exposed to dirt and grit, inducing rapid wear and a constant menace to safety.

Nuttall does it this way

Is there any question in your mind which way is better? And notice the saving in space.



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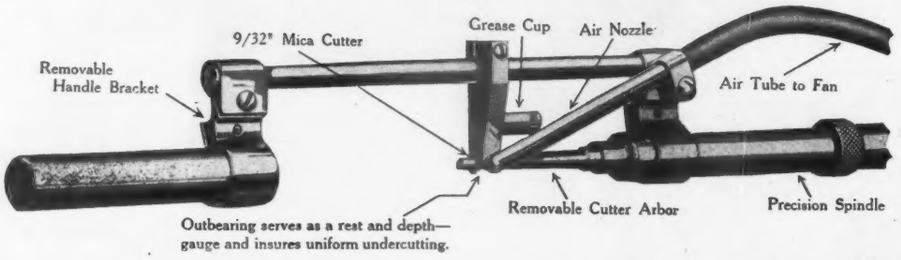

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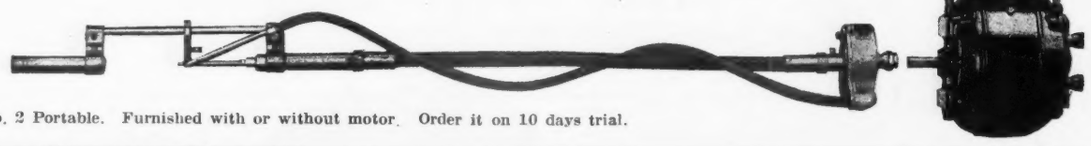

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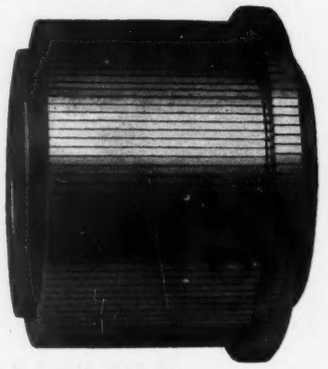

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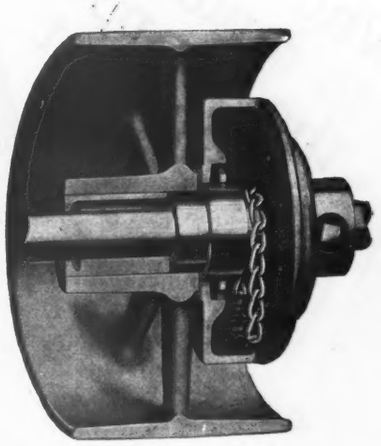
E. 49th & St. Clair Ave., Cleveland, O.

Better benches for less money!

"HALLOWELL" all-steel benches are carried in stock. You can get them quickly—no lumber to order, no carpenters to hire. "Hallowell" benches are shipped *complete*—bolts and all. All-steel "Hallowell" bench drawers, with lock, protect tools. Steel tables, steel tool stands, steel bench legs, etc., are also in stock. They are built the "Hallowell" way, good-looking and durable.

Loose pulleys really oiled!

YOU'VE heard dozens of claims about loose pulley oiling. The "Gast" really does the job —*oils loose pulleys perfectly*! Yes, it's a chain-type oiler but an entirely new principle. Perfect film of oil at all speeds. Once or twice a year you replenish the oil reservoir—and that's all there is to it! No more nuisance, no more delays, no more expense—yes, the "Gast" will pay for itself in 7 to 12 months. Of course, you don't have to believe all this—but you can try a "Gast" for 30 days *free* and then decide for yourself. You've never seen anything like the "Gast," so better look at our new circular, then order in an Oiler on trial. That way, the "Gast" does its own selling!



Write today, for free illustrated folders!

Standard Pressed Steel Co.

Box 14, Jenkintown, Pa.

Are you ready for the clean up that's coming?
Who's going to replace the scrapped equipment

Maintenance? Replacement?

MANUFACTURERS who prize good-will and new business will recognize such objectives in the plans for our February issue:—good-will by enough attention to existing installations to insure satisfactory performance; incidentally a satisfied customer, and new business in the replacement of antiquated or misapplied apparatus. We are making it easy for the reader to ask nine searching questions about his plant equipment.

MAINTENANCE *will be prompted by these questions:*

1. Has equipment been thoroughly inspected?
2. Will minor repairs assure satisfactory operation?
3. Is equipment now O.K.?

REPLACEMENT *suggests itself from the replies to questions four to nine inclusive:*

4. What major repairs are required?
5. What is estimated cost of repair?
6. What has been total repair cost to date?
7. How long has this equipment been in service?
8. What would cost be to replace with modern equipment?
9. Should equipment be repaired or should it be replaced?

IT WILL be suggested to the reader that he talk over his problems with manufacturers. Here is an earnest effort to be of service to the reader of *Industrial Engineer*. Advertisers may fit into a movement for Maintenance when necessary and Replacement where advisable.

Ask for full details of the plan.

ABC INDUSTRIAL ENGINEER ABP

A McGraw-Hill Publication

Tenth Avenue at 36th Street, New York

SEARCHLIGHT SECTION

EMPLOYMENT-BUSINESS OPPORTUNITIES-EQUIPMENT

UNDISPLAYED—RATE PER WORD:

Positions Wanted, 4 cents a word, minimum 75 cents an insertion, payable in advance.

Positions Vacant and all other classifications, 8 cents a word, minimum charge $2.00.

Proposals, 40 cents a line an insertion.

INFORMATION:

Box Numbers in care of any of our offices count 10 words additional in undisplayed ads.

Discount of 10% if one payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

DISPLAYED—RATE PER INCH:

1 to 3 inches.....$5.00 an inch
4 to 7 inches..... 4.80 an inch
8 to 14 inches..... 4.60 an inch

An advertising inch is measured vertically on one column, 3 columns—30 inches—to a page.

I. E.

POSITIONS VACANT

ARMATURE winder, man thoroughly experienced on A.C. rewinding and general motor repairing. Must be able to shoot trouble and run lathe. Steady position in modern shop. Electric Service Repair Co., 2nd floor, 45 Fair St., Paterson, N. J.

A SHOP foreman wanted for a large electric repair shop; must have had wide experience in handling help and capable of operating a shop of sixty or more workers; do not apply unless you have these qualifications; this shop is in the vicinity of Troy, N. Y. P-223, Industrial Engineer, Tenth Ave. at 36th St., New York.

COST accountant wanted, young man with sufficient training and experience in modern cost methods to work out and install cost system in plant with three hundred (300) employees in Northeastern Pennsylvania. Excellent opportunity for man with energy, tact, and initiative. Give full details of experience, education and salary. P-225, Industrial Engineer, 1600 Arch St., Phila., Pa.

MILLWRIGHT wanted, capable of installing electric motors; this means not one but several thousand; must be able to handle help and get results; steady position to the right man; this work is in the vicinity of Troy, N. Y. P-222, Industrial Engineer, Tenth Ave. at 36th St., New York.

WANTED: Young men to become service experts and maintenance men for high-grade mechanical and electrical equipment as used in large industrial plants and factories in electrically controlling and recording temperature and pressure. Excellent opportunities for promotion after thorough course of training in factory of large manufacturer of instruments and controllers. In applying describe mechanical ability, previous experience if any and education. Young single men preferred who are free for quick transfers. P-226, Industrial Engineer, Tenth Ave. at 36th St., New York.

EMPLOYMENT SERVICE

IF you are qualified for position between $2,500 and $25,000, and are receptive to negotiations for new connection, your response to this announcement is invited. The undersigned provides a thoroughly organized service, established sixteen years ago, to conduct confidential preliminaries, and assist the qualified man in locating the particular position he desires. Not an employment agency. Retaining fee protected by refund provision, as stipulated in our agreement. Send name and address only for description of service. R. W. Bixby, Inc., 258 Main Street, Buffalo, New York.

BE A METER ENGINEER

Get in the new profession. We can teach you meter engineering *by mail* at your own home during spare time. Successful graduates everywhere.

EARN $3,600.00 A YEAR

Central stations must have Electrical Meter Engineers. They pay high salaries. Write today, just your name and address on a postal and we will send you full particulars free. Ft. Wayne Correspondence School, Dept. 80, Ft. Wayne, Ind.

Distributors WANTED

WE are an old established highly rated concern and desire to make a few more permanent connections with Manufacturer's Agents and Distributors on an exclusive sales agency basis, who have proper connections and are in position to handle a fair volume of business. We manufacture the following lines of Ball Bearing Machines:

D. C. Commutating Pole Machines
A. C. Squirrel Cage Motors.
A. C. Slip-Ring Motors.
A. C. Double Squirrel Cage. Motors.
A. C. Multi-Speed Motors.

These machines are built in ratings up to 75 hp. and in all of the standard modifications. If interested, get in touch with us as we have a profitable proposition to offer.

AS-210, Industrial Engineer
7 South Dearborn St., Chicago, Ill.

MOTOR BARGAINS

New and Used

WE can supply your motor needs in any horsepower, A.C. or D.C., any type or make. Also motor-generator sets of all characteristics. Our motor service is complete. We buy, sell, rent, exchange or repair. Every motor guaranteed for one year against all electrical or mechanical defects. Write for our prices.

L. J. LAND 144 GRAND ST NEW YORK CITY

MOTOR MACHINERY Bought Rented Exchanged

We can save you considerable money on your motor and machinery needs. Large stock to select from. Everything guaranteed. Write.

Freidus Machy. Co. 174 Centre St., New York City.

MOTORS NEW and REBUILT

Buy With Confidence

Every Motor Guaranteed to Make Good or We Will.

ELECTRIC MOTORS CORP.
170 Centre St., New York, N. Y.

WANTED

Editorial Assistant

WANTED

Must be graduate electrical engineer with several years' good, industrial operating and maintenance experience, preferably in steel mill. Editorial experience not essential, but must write well. Excellent opportunity. Location New York. Give complete details, training, age, salary.

P-224, Industrial Engineer
Tenth Ave. at 36th St., New York City

A Fractional HP Motor or a Complete Power Plant

SAVE 35 to 45%

Buy Properly Rebuilt Electrical Power Equipment

Every machine completely overhauled and tested – Guaranteed

Write for Stock Bulletin

The FUERST-FRIEDMAN Co.
CLEVELAND, OHIO

WE BUY

ELECTRIC MOTORS

America's Pioneer Electrical Bargain House, Established 1893—High grade motors—generators, meters, transformers. Bought, sold, rented, exchanged. A $500,000 stock always available.

GREGORY ELECTRIC CO.
Works, 16th and Lincoln and Wood Sts., Chicago, Ill.

WANTED

USED TRANSFORMER

From 250 kva. to 450 kva., 11,000 to 220 v., 25 cy., 3 ph., self-cooled oil, indoor type. Will also consider 3 single phase Transformers. *Please furnish a complete description of what you have.*

KEOKUK STEEL CASTING CO.
Keokuk, Iowa.

Quality
Service

Right Prices
Courteous Treatment

EXPECT THESE QUALITIES IN YOUR MOTOR

1. Quiet operation (very important).
2. Interchangeable external dimensions for A.C. and D.C. in more than 80% of ratings.
3. Perfect dynamic balance.
4. Box type frames, feet integral, lessening skewing.
5. Heavy bearing brackets, lessening vibration.
6. Extra large bronze bearings, well lubricated.
7. Large oil reservoirs.
8. Indestructible Rotor construction.
9. Forced ventilation.

Built on a Creed **Imperial** Motors and Generators *Meet These Specifications*

THE IMPERIAL ELECTRIC CO.

FACTORY: AKRON, OHIO

BRANCHES

NEW YORK, N. Y. 253 Broadway
BALTIMORE, MD. 22nd & Maryland Ave.
CHICAGO, ILL. 9 So. Clinton St.
CLEVELAND, O. 442 Rockefeller Bldg.
MILWAUKEE, WIS. 236-24th St.
PHILADELPHIA, PA. 2019 Rittenhouse St.
COLUMBUS, O. 319 Citizens Bank Bldg.
GRAND RAPIDS, MICH. 336½ Michigan Trust Bldg.
ST. LOUIS, MO. 301 Buder Bldg.
CINCINNATI, O. 14 Greenwood Bldg.

WHAT AND WHERE TO BUY

Equipment, Apparatus and Supplies Advertised in this Issue with Names of Manufacturers and Distributors

Prospective purchasers in the electrical-mechanical market are invited to apprise us of their needs, assuming, of course, that the articles sought are not listed here.

Air Compressors
Allis-Chalmers Mfg. Co.

Ammeters, Voltmeters
(See Instruments, Electrical).

Armature Bearings
Rollway Bearing Co., Inc.

Armature Coil Spreaders
Armature Coil Equipment Co.
Mutual Foundry & Machine Co.

Armature Coil Winders
Armature Coil Equipment Co.
Mutual Foundry & Machine Co.

Armature Repair Machinery
Armature Coil Equipment Co.
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Barrels, Steel Shop
The Kirk & Blum Mfg. Co.

Batteries
Dry
National Carbon Co.
Storage
Electric Storage Battery

Battery Charging Apparatus
General Electric Co.
Westinghouse Electric & Mfg. Co.

Battery Parts
Electric Storage Battery Co.

Bearings
Ball
Dodge Mfg. Corp.
Fafnir Bearing Co.
New Departure Mfg. Co., The
Norma Hoffman Co.
Skayef Ball Bearing Co.
Roller
Norma Hoffman Co.
Rollway Bearing Co., Inc.
Standard Pressed Steel Co.
Timken Roller Bearing Co., The

Bearing Metal
Dodge Mfg. Corp.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Bed Plates
Foote Bros. Gear & Mach. Co.

Bells, Electric
Schwarze Electric Co.
Westinghouse Electric & Mfg. Co.

Belts, Conveyor
Link-Belt Co.

Belt Dressing
Cling Surface Co.
Standard Oil Co., Ind.

Belts, Transmission
Link-Belt Co.

Bench Legs
Standard Pressed Steel Co.

Bleachers
Worcester Bleach & Dye Works Co.

Blocks, Pillow
Fafnir Bearing Co.
Rollway Bearing Co., Inc.
Standard Pressed Steel Co.
Weller Mfg. Co.

Blowers
Clements Mfg. Co.
De Laval Steam Turbine Co.
Green Equipment Corp.
Kirk & Blum Mfg. Co.
Martindale Electric Co.
Sturtevant Co., B. F.
Centrifugal
De Laval Steam Turbine Co.
Portable
Porter & Ross, Inc.

Blow-Pipe Systems
The Kirk & Blum Mfg. Co.

Bobs
Philadelphia Gear Works

Bolts, Nuts and Screws
Nat'l. Screw & Mfg. Co.
Sturtevant Co., B. F.

Books, Technical
McGraw-Hill Book Co., Inc.

Boosters
Allis-Chalmers Mfg. Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Boxes
Clamp
Standard Pressed Steel Co.
Flood Outlet
Adam Electric Co., Frank
Hubbell, Inc., Harvey
Hanger
Fafnir Bearing Co.
Junction and Outlet
General Electric Co.
Hubbell, Inc., Harvey
Trumbull Electric Mfg. Co.
Westinghouse Electric & Mfg. Co.
Meter and Service
General Electric Co.
Trumbull Electric Mfg. Co.
Westinghouse Electric & Mfg. Co.
Sheet Metal Tote
The Kirk & Blum Mfg. Co.

Brakes
Crane
Clark Controller Co.
Electric Controller & Mfg. Co.
Westinghouse Electric & Mfg. Co.
Disc
Westinghouse Electric & Mfg. Co.
Electric
Clark Controller Co.
Electric Controller & Mfg. Co.
Westinghouse Electric & Mfg. Co.

Brushes
Commutator
Baylis Co., The
Calebaugh Self Lubricating Carbon Co.
Carbon Engineering Co.
General Electric Co.
Jeandron, W. J.
Morganite Brush Co., Inc.
National Carbon Co.
Westinghouse Electric & Mfg. Co.
Dynamic and Carbon
Jeandron, W. J.
Morganite Brush Co., Inc.
National Carbon Co.
Westinghouse Electric & Mfg. Co.

Brush Holders
Baylis Company
Flower, D. B.
Westinghouse Electric & Mfg. Co.

Bus Bar Supports
General Electric Co.
Westinghouse Electric & Mfg. Co.

Bushings
Standard Pressed Steel Co.

Cables (See Wire & Cable)

Cable Accessories
Dossert & Co.
Electric Service Supplies Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Carbon Brushes
(See Brushes)

Castings, Steel
Falk Corp.

Cement
Commutator
Green Equip. Corp.
Martindale Electric Co.

Chains, Power Transmission
Diamond Chain & Mfg. Co.
Link-Belt Co.
Morse Chain Co.
Philadelphia Gear Works

Circuit Breakers
Condit Electrical Mfg. Co.
Cutter Co.
General Electric Co.
Roller-Smith Co.
Sundh Electric Co.
Westinghouse Electric & Mfg. Co.

Clamps
Electric Service Suplies Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

Cleats
Square D. Co.

Clutches
Dodge Mfg. Corp.
Weller Mfg. Co.
Friction
Allis-Chalmers Mfg. Co.
Conway Clutch Co.
Link-Belt Co.
Magnetic
Cutler Hammer Mfg. Co.

Coal and Ash Handling Equipment
Dodge Mfg. Corp.
Link-Belt Co.

Coil Winding Machines
Armature Coil Equipment Co.
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Coil Winding Tools
Mutual Foundry & Machine Co.

Coils
Choke
American Transformer Co.
Electric Service Supplies Co.
General Electric Co.
Porter & Ross, Inc.
Westinghouse Electric & Mfg. Co.

For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 102.

Coils, Induction
American Transformer Co.

Commutator Cement
Porter & Ross, Inc.

Commutator Slotters
Porter & Ross, Inc.

Commutator Stones
Porter & Ross, Inc.

Compensaters
Automatic
Electrical Service Supplies Co.
General Electric Co.
Industrial Controller Co.
Westinghouse Electric & Mfg. Co.
Manual
Allis-Chalmers Mfg. Co.
Fairbanks-Morse Co.
General Eectric Co.
Industrial Controller Co.
Westinghouse Electric & Mfg. Co.

Compressors, Centrifugal
De Laval Steam Turbine Co.

Conductors, Armored
Tubular Woven Fabric Co.

Conduit Fittings
Erie Malleable Iron Co.

Conduits
American Circular Loom Co.
American Wiremold Co.
Tubular Woven Fabric Co.

Connectors and Terminals
Dossert & Co.
General Electric Co.
Ohio Elect. & Cont. Co.
Westinghouse Electric & Mfg. Co.

Control Systems
Monitor Controller Co.

Controllers
Armored for Electric Circuits
Ohio Elec. & Controller Co.
Automatic
Allen-Bradley Co.
Clark Controller Co.
Cutler Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Monitor Controller Co.
Rowan Controller Co.
Russell Mfg. Co.
Sundh Electric Co.
Westinghouse Electric & Mfg. Co.
Crane
Electric Controller & Mfg. Co.
Monitor Controller Co.
Electric
Industrial Controller Co.
Monitor Controller Co.
Ohio Elect. & Cont. Co.
Finger
Russell Mfg. Co.
Motor
Allen-Bradley Co.
Allis-Chalmers Mfg. Co.
Clark Controller Co.
Condit Electric Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Monitor Controller Co.
Rowan Controller Co.
Square D. Co.
Sundh Electric Co.
Russell Mfg. Co.
Union Electric Co.
Westinghouse Electric & Mfg. Co.
Rheostatic
Monitor Controller Co.
Reversible
Russell Mfg. Co.
Speed
Clark Controller Co.
Monitor Controller Co.

Temperature and Pressure
Taylor Instrument Co.

Conveyors
Link-Belt Co.
Weller Mfg. Co.

Conveyors, Gravity
Standard Conveyor Co.

Cord, Flexible
Hubbell, Inc., Harvey
Okonite Co., The
Rome Wire Co.
Tubular Woven Fabric Co.
U. S. Rubber Co.

Cotton Yarns
Worcester Bleach & Dye Works Co.

Couplings, Flexible
Allis-Chalmers Mfg. Co.
Clark Controller Co.
De Laval Steam Turbine Co.
Dodge Mfg. Corp.
Falk Corp.
Nuttall Co., R. D.
Philadelphia Gear Works
Smith & Serrell

Couplings, Shaft
Standard Pressed Steel Co.

Crane Controllers
Allen-Bradley Co.
Clark Controller Co.

Crane Motors
Sundh Electric Co.
Westinghouse Electric & Mfg. Co.

Cranes, Portable Electric
Elwell-Parker Co.
Shepard Electric Crane & Hoist Co.

Cross Arms
Electric Service Supplies Co.

Cutouts
General Electric Co.
Hubbell, Inc., Harvey
Square D. Co.
Trumbull Elec. & Mfg. Co.
Westinghouse Electric & Mfg. Co.

Cutters
Hole
Koch & Co., Paul W.
Commutator Slotting
Hullhorst Micro Tool Co.

Diagrams, Winding
McGraw-Hill Book Co., Inc.

Drives
Belt
F. L. Smidth & Co.
Silent Chain
Link-Belt Co.

Dust Collecting Systems
Kirk & Blum Mfg. Co.

Dynamos
(See Generators & Motors)

Electric Lighting
Westinghouse Electric & Mfg. Co.

Elevators & Conveyors
Dodge Mfg. Corp.
Link-Belt Co.

Electric Testing Sets
Porter & Ross, Inc.

Enamels, Wire, Wood and Steel
Impervious Varnish Co.
Sterling Varnish Co.
Baking
Benolite Co., Inc.

Okonite Tapes

Splice once and for all

WHY waste time and money trying to make permanent joints with inferior tapes?

With OKONITE TAPES you make splices *once and for all* which will be as strong electrically and as long-lived as the insulation on the wire itself.

Ask about OKONITE TAPE, the rubber insulating tape made with the same high grade rubber, compounding ingredients, and care that characterizes OKONITE insulation.

MANSON TAPE, the rubber filled cloth tape for the Mechanical protection of joints, is unequalled in weathering quality and supreme for any service where the best is the first consideration.

DUNDEE "A" and "B" TAPES, the next best friction tapes on the market, are suitable where conditions do not warrant the extra expense of Manson.

Write to our nearest Office for Samples and Booklet

The Okonite Company

The Okonite-Callender Cable Company, Inc.

Factories, PASSAIC, N. J. PATERSON, N. J.

Sales Offices: New York, Chicago, Pittsburgh, St. Louis, Atlanta, Birmingham, San Francisco, Los Angeles, Seattle

F. D. Lawrence Electric Co., Cincinnati, O.
Novelty Electric Co., Phila., Pa. Pettingell-Andrews Co., Boston, Mass.
Canadian Representatives: Engineering Materials Limited, Montreal
Cuban Representatives: Victor G. Mendoza Co., Havana

Engineers, Illuminating
Westinghouse Electric & Mfg. Co.

Engines, Oil
Allis-Chalmers Mfg. Co.
Fairbanks-Morse & Co.

Factory Furniture
Standard Pressed Steel
Westinghouse Electric & Mfg. Co.

Fan Hangers, Electric
Adam Electric Co., Frank

Fan Motors
General Electric Co.
Kirk & Blum Mfg. Co.
Westinghouse Electric & Mfg. Co.

Fans
Exhaust and Ventilating
General Eectric Co.
The Kirk & Blum Mfg. Co.
National Screw & Mfg. Co.
Star Electric Motor Co.
Sturtevant Co., B. F.
Westinghouse Electric & Mfg. Co.

Files, Commutator Slotting
Martindale Electric Co.

Fittings
Pipe
Westinghouse Electric & Mfg. Co.

Financial
Hornblower & Weeks

Fixtures, Lighting
American Fixture Co.
The Holophane Co.
Westinghouse Electric & Mfg. Co.
Industrial
Benjamin Electric Co.

Fire Extinguishers
The Fyr-Fyter Co.

Furnaces, Electric
General Electric Co.
Westinghouse Electric & Mfg. Co.

Fuse Clips
Reinforced Switch & Mfg. Co.
Trumbull Electric Mfg. Co.

Fuse Plugs
Hubbell, Inc., Harvey
Pierce Renewable Fuses, Inc.
Trico Fuse Mfg. Co.
Westinghouse Electric & Mfg. Co.

Fuses
General Electric Co.
Pierce Renewable Fuses, Inc.
Trico Fuse Mfg. Co.
Renewable
Bussmann Mfg. Co.
Pierce Renewable Fuses, Inc.
Trico Fuse Mfg. Co.
Westinghouse Electric & Mfg. Co.
Non-Renewable
Trico Fuse Mfg. Co.

Gears
Cleveland Worm & Gear Co.
Dodge Mfg. Corp.
Falk Corp.
Foote Bros. Gear & Mach. Co.
General Electric Co.
Horsburgh & Scott Co., The
James Mfg. Co., D. O.
Link-Belt Co.
Morse Chain Co.
Nuttall Co., R. D.
Philadelphia Gear Works
Smith, Winfield H.
Westinghouse Electric & Mfg. Co.
Composition
Formica Insulation Co., The
General Electric Co.
Westinghouse Electric & Mfg. Co.
Forged
Philadelphia Gear Works
Helical
De Laval Steam Turbine Co.
Falk Corp.
Foote Bros. Gear & Mach. Co.
James Mfg. Co., Do.
Herringbone
Falk Corp.
Foote Bros. Gear & Mach. Co.
Horsburgh & Scott Co., The
Double Helical
De Laval Steam Turbine Co.
Reducing
Cleveland Worm & Gear Co.
Foote Bros. Gear & Mach. Co.
Winfield H. Smith
Spiral
Foote Bros. Gear & Mach. Co.
Horsburgh & Scott Co., The
Worm
De Laval Steam Turbine Co.
Horsburgh & Scott Co., The

Gear Blanks
Non-Metalic
The Formica Co.

Generating Sets
Allis-Chalmers Mfg. Co.
Crocker-Wheeler Co.
General Electric Co.
Marble-Card Electric Co.
Triumph Electric Co.
Westinghouse Electric & Mfg. Co.

Generators
Allis-Chalmers Mfg. Co.
Bodine Electric Co.
Crocker-Wheeler Co.
Electro Dynamic Co.
General Electric Co.
Lincoln Electric Co.
Marble-Card Elec. Co.
Reliance Electric & Eng. Co.
Star Electric Motor Co.
Triumph Electric Co.
Westinghouse Electric & Mfg. Co.

Glue Pots
Westinghouse Eectric & Mfg. Co.

Grinders
Bodine Electric Co.
Martindale Electric Co.
Tool
Fafnir Bearing Co.
Grinding Appliances
F. L. Smidth & Co.

Grounding Devices
Dossert & Co.

Guards, Machinery
The Kirk & Blum Mfg. Co.

Hangers, Line Shaft
American Pulley Co.
Dodge Mfg. Corp.
Fafnir Bearing Co.
Link-Belt Co.
Rollway Bearing Co., Inc.
Standard Pressed Steel Co.
Thompson Elec. Co.

Hangers, Post
Standard Pressed Steel Co.

Heating and Ventilating
The Kirk & Blum Mfg. Co.

Heating Devices, Industrial
General Electric Co.
Westinghouse Electric & Mfg. Co.
Wiegand Co., E. L.

Hoists, Electric
General Electric Co.
Link-Belt Co.
Shepard Electric Crane & Hoist Co.

Hydraulic Turbines
De Laval Steam Turbine Co.

Indicators, Speed
(See Tachometers).

Industrial Ovens
The Kirk & Blum Mfg. Co.

Instrument Transformers
American Transformer Co.
General Electric Co.
Roller-Smith Co.
Westinghouse Electric & Mfg. Co.

Instruments, Electrical
Graphic
General Electric Co.
Jewell Electrical Instrument Co.
Westinghouse Electric & Mfg. Co.
Indicating
Biddle, James G.
General Electric Co.
Jewell Electrical Instrument Co.
Roller-Smith Co.
Taylor Instrument Co.
Westinghouse Electric & Mfg. Co.
Weston Electrical Instrument Corp.
Integrating
General Electric Co.
Jewell Electrical Instrument Co.
Westinghouse Electric & Mfg. Co.
Scientific and Testing Services
Biddle, James G.
General Electric Co.
Jewell Electrical Instrument Co.
Roller-Smith Co.
Westinghouse Electric & Mfg. Co.
Weston Electrical Instrument Co.

Insulating Material
Comp. Cloth and Paper
General Electric Co.
Mica Insulator Co.
Westinghouse Electric & Mfg. Co.
Compounds, Paints and Varnishes
Benolite Co., Inc.
Dolph Co., John C.
General Electric Co.
Impervious Varnish Co.
Irvington Varnish & Insulator Co.
Martindale Electric Co.
Mica Insulator Co.
Okonite Co.
Sterling Varnish Co.
Westinghouse Electric & Mfg. Co.
Fibre, Tape and Webbing
Irvington Varnish & Insulator Co.

Insulators
Electric Service Supplies Co.
General Electric Co.
Irvington Varnish & Insulator Co.
Square D. Co.
Westinghouse Electric & Mfg. Co.
Fibre
General Electric Co.
Tape and Webbing
General Electric Co.
Mica Insulator Co.
Okonite Co., The
U. S. Rubber Co.
Westinghouse Electric & Mfg. Co.

Investments
Hornblower & Weeks

Joints
Cable Splicing
Dossert & Co.

Lamp Guards
Electric Service Supplies Co.
Hubbell, Inc., Harvey
Westinghouse Electric & Mfg. Co.

Lamp Locks
Ren Mfg. Co.

Lamps
Arc
General Electric Co.
Westinghouse Electric & Mfg. Co.
Incandescent
General Electric Co.
The Holophane Co.
Nitrogen
Westinghouse Electric & Mfg. Co.

Lifting Magnets
Electric Controller & Mfg. Co.
Ohio Elect. & Cont. Co.

Lighting, Industrial
American Fixture Co.
General Electric Co.
The Holophane Co.
National Screw & Mfg. Co.
Westinghouse Electric & Mfg. Co.

Lightning Arresters
Electric Service Supplies Co.
General Electric Co.
Westinghouse Electric & Mfg. Co.

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Lubricants
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Foote Bros. Gear & Mach. Co.

Magnetic Separators
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Dodge Mfg. Corp.
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Meter Testers
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Raw and Products
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Mica Under Cutting Machines
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Appleton Electric Co.

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Ohio Elect. & Cont. Co.
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Triumph Electric Co.
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Ohio Elec. & Controller Co.
Fractional H. P.
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Bodine Electric Co.

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Gits Brothers Mfg. Co.

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Falk Corp.

Oil Gages
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Biddle, James G.
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Rollway Bearing Co., Inc.
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Standard Pressed Steel Co.

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Electric Service Supplies Co.
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Benolite Co., Inc.

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De Laval Steam Turbine Co.
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Allis-Chalmers Mfg. Co.
Stock
De Laval Steam Turbine Co.

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Taylor Instrument Co.

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Tirex

—the cable to specify for motor leads

Electric railways are regularly using TIREX Motor Lead Cable because they find it eliminates the costly cable lead troubles as one of their problems.

Electric railway engineers were quick to learn the admirable qualities of TIREX Cables for motor leads. *And any cable that will stand the rugged service required in electric railway operation, is a good cable to specify for your own motor leads.*

TIREX is as flexible as a rubber hose. Note the multiplicity of fine wires which make up the copper conductor. The conductors are insulated with a high grade rubber compound and the cable is protected by TIREX "rubber armor" which is almost wear-proof and satisfactory for all kinds of rough work.

Notice, too, the special feature which distinguishes TIREX Motor Lead Cables from the regular line of TIREX Cables, the paper tape between the copper and rubber. "Skinning" cable for connections is easy because when the insulation is removed the conductor is left clean, ready for connecting to motor terminals.

Get all the facts on this splendid indestructible cable.

Use the coupon.

SIMPLEX WIRE & CABLE Co

MANUFACTURERS

201 DEVONSHIRE ST., BOSTON

New York Chicago San Francisco Cleveland Jacksonville

Simplex Wire & Cable Co.,
201 Devonshire St., Boston, Mass.

Gentlemen:—

Please send me the Simplex Manual. ☐

Please send quotation on Tirex Motor Lead Cables. ☐

Size.....No. of Conductors.....

Voltage..... Feet.....

Name .....

Position .....

Company .....

Address .....

City .....

State .....

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Controller
Monitor Controller Co.
Induction Voltage
General Electric Co.
Westinghouse Eilectric & Mfg. Co.
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Electric Controller & Mfg. Co.
Speed
Industrial Controller Co.
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Standard Pressed Steel Co.

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Hollow, Cap and Set
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Standard Pressed Steel Co.
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(See Searchlight Section)
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Westinghouse Electric & Mfg. Co.
Wiegand Co., Edwin L.

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Foote Bros. Gear & Mach. Co.
Horsburgh & Scott Co., The
James Mfg. Co., D. O.
Philadelphia Gear Works
Smith, Winfield, H.

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Morse Chain Co.

Speed Transformers
De Laval Steam Turbine Co.

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Dodge Mfg. Corp.
James Mfg. Co., D. O.
Link-Belt Co.
Morse Chain Co.
Philadelphia Gear Works

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(See Controllers)

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De Laval Steam Turbine Co.

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Green Equipment Corp.
Martindale Electric Co.

Strip Heaters
Westinghouse Electric & Mfg. Co.
Wiegand Co., Edwin L.

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General Electric Co.
The Holophane Co.
Westinghouse Elec. & Mfg. Co.

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Green Equipment Corp.
General Electric Co.
Hubbell, Inc., Harvey
Lincoln Electric Co.
Westinghouse Elec. & Mfg. Co.

Supplies, Railway
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

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Westinghouse Elec. & Mfg. Co.

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Industrial Controller Co.
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General Electric Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.
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Monitor Controller Co.
Rowan Controller Co.
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Electric Controller & Mfg. Co.
General Electric Co.
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Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Monitor Controller Co.
Rowan Controller Co.
Sundh Electric Co.
Westinghouse Elec. & Mfg. Co.
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Adam Electric Co., Frank
General Electric Co.
Square D Co.
Trumbull Electric Mfg. Co.
Trumbull-Vanderpoel Electric Co.
Westinghouse Elec. & Mfg. Co.
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Electric Controller & Mfg. Co.
General Electric Co.
Monitor Controller Co.
Westinghouse Elec. & Mfg. Co.
Snap
Hubbell, Inc., Harvey
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Westinghouse Elec. & Mfg. Co.
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Biddle, James G.
Westinghouse Elec. & Mfg. Co.

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The Kirk & Blum Mfg. Co.

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Friction
Porter & Ross, Inc.
Rubber
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Mica Insulator Co.
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Biddle, James G.
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Roller-Smith Co.
Square D Co.
Westinghouse Elec. & Mfg. Co.
Weston Electrical Ins't. Corp.

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Taylor Instrument Co.

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Koch & Co., Paul W.
Electric
Porter & Ross, Inc.

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Reeves Pulley Co.
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Reeves Pulley Co.

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Elwell-Parker Electric Co.

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American Circular Loom Co.

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Hullhorst Micro Tool Co.

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Benolite Co., Inc.
Sterling Varnish Co.

Varnishes, Cable
Impervious Varnish Co.
Mica Insulator Co.
Sterling Varnish Co.

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Welders
Arc
Burke Electric Co.
General Electric Co.
Lincoln Electric Co.
Westinghouse Elec. & Mfg. Co.
Electric
Lincoln Electric Co.

Welding Machines
General Electric Co.
Westinghouse Elec. & Mfg. Co.

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Rockbestos Co.
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American Insulated Wire & Cable Co.
American Steel & Wire Co.
Rome Wire Co.
Enameled
Maring Wire Co.
Insulated
American Steel & Wire Co.
Okonite Co., The
Tubular Woven Fabric Co.
York Insulated Wire Co.
Magnet
American Steel & Wire Co.
Maring Wire Co.
Porter & Ross, Inc.
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Rome Wire Co.
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For Dipping and Baking

Dipping with Irvington Varnish and then baking will make your armatures good for many years' additional service. Prepare now for the heavy overloads of winter time operation. Place that order today. Our nearest sales representative will be prompt in serving you.

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Irvington, N. J.

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Ball Bearing

Single Phase Repulsion Type
Direct Current
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Horizontal & Vertical Design
Semi and Totally Enclosed
Back Geared

Superior in Quality
Competitive in Price

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REG. U.S. PAT. OFF.

Heavy Duty Portable Cord

You can treat it rough!

Take a tip from the big boys—they pick Duracord 'cause it won't quit on the job, it's tough, stands abuse, and lasts longer. Put Duracord on yer toughest job—and see for yerself.

Dura Bill

Your Electrical Jobber stocks DURACORD
It's one of the DURABILT PRODUCTS

Made by the Tubular Woven Fabric Company,
Pawtucket, R. I.

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BENOLITE INSULATING VARNISHES

do more than form a barrier against electric current.

They afford protection against

Heat, because they have extra long life.
Moisture, because they are moisture resisting.
Abrasion, because they are hard and tough.
Vibration, because they possess excellent binding qualities.

They afford protection against inferiority in varnishes because they

Are made by experienced varnish makers.
Supervised by interested executives.
Specified by practical engineers.
Used by exacting repair shops.

Why not adopt Benolite Varnishes in your plant and minimize insulating costs? We will be pleased to have our engineers specify for your requirements

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BENOLITE COMPANY

Laboratories: MANOR - PA.

This advertisement may be read by an engineer who understands electricity from A to Z. It may be read by an executive who knows little or nothing about it. Yet, both are interested in giving their plant equipment the finest protection they can secure.

U-Re-Lite has been built out of an experience that dates back over 38 years in the Circuit Breaker art. You can get nothing finer—nothing more dependable—nothing more economical and trouble-free in operation than U-Re-Lite—for absolute protection against the ever-present dangers of short circuits and electrical overloads.

A copy of the ninety-six page U-Re-Lite handbook will be mailed on request

CUTTER

U-RE-LITE I-T-E CIRCUIT BREAKERS

THE CUTTER COMPANY — *Established in 1888* — PHILADELPHIA, PENNSYLVANIA

As they Say at John B. Stetson Company

Class 7107 D. C. Starter—Time Limit Acceleration

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"These automatic starters are easy to install and cost little to maintain. Many of our I-C starters are equipped with overload relays, which protect motors and machinery, and save time lost in locating and replacing blown fuses.

"Service from Industrial Controller Company has been very satisfactory."

Industrial Controller Co.

MILWAUKEE, WIS. U.S.A.

End